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U.S. SUPERCOMPUTER INDUSTRY

HEARING

BEFORE THE

SUBCOMMITTEE ON
SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED FIRST CONGRESS

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U.S. SUPERCOMPUTER INDUSTRY

TUESDAY, JUNE 20, 1989

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY,
Washington, D. C.

The subcommittee met, pursuant to call, at 1:35 p.m., in Room 2318, Rayburn House Office Building, Hon. Doug Walgren [chairman of the subcommittee], presiding.

Mr. WALGREN. Well, let me invite Senator Gore to join us at the witness table when it makes sense, and bring us to order.

Without objection, any video or cameras or other kinds of photography will be permitted in the hearing today, and that will be the order.

Too often in the past several years, we have watched as American companies lost out in the international marketplace for high technology products invented or first developed in the United States. And we approach this hearing on the United States supercomputer industry with that same kind of vague, uncomfortable feeling that it may be happening again.

The health of the United States supercomputer industry is of real public concern. Supercomputers have become powerful and irreplaceable tools in scientific research, in product and process development, and in many aspects of manufacturing. Supercomputers are used to predict the weather, to design buildings, design and manufacture aircraft and automobiles, to locate oil reserves, to design new drugs. They are also indispensable in certain national defense areas involving electronic intelligence, nuclear weapons design; and, I think we all know that this kind of scale above the normal capabilities in computing technology is something that will be integral to the future capabilities that man seeks to develop and therefore integral to the United States' future as well.

To promote our economic competitiveness and national security, it is essential that the U.S. industry, the defense establishment, and the research and development community have access to the most powerful scientific computers available at any time. And it is, therefore, appropriate to explore whether or not we need new Federal roles and new Federal policies to bolster the high performance computer industry.

This afternoon, we have a distinguished group of representatives of the U.S. supercomputer industry who will give us their views and comment on their experience on the competitive position of our domestic manufacturers. They will also provide their views on what role the Federal Government should try to play in helping to

maintain the strength of the United States supercomputer industry and develop it further. We seek to explore the foreign threat to the U.S. high performance computer industry, as well as to create a record discussing the trends in hardware and software which will affect the nature of the supercomputer market in the future.

We have as our first witness today the distinguished Senator from Tennessee, the Honorable Albert Gore, who many of you remember years ago starting in the Congress on the House Science and Technology Committee. Senator Gore has been a forceful proponent for a strong national effort in high performance scientific computing, from the initial groundwork that he helped lay for the National Science Foundation's Supercomputing Centers to the ongoing interest and the focus that he has given to the problem of developing networks for this kind of capability in the Senate. He has been the leader in the Congress concerned with supercomputers. We are pleased to have him here today and to welcome his thoughts in this area.

Before I introduce him—well, I think let's stop there, and let's turn to our panelists later. I want to introduce my distinguished minority leader, Sherry Boehlert, for any comments he may have, and then we'll turn to Senator Gore.

Mr. BOEHLERT. Thank you, Mr. Chairman. This is a pivotal time for the American supercomputer industry. Pivotal not only because it faces growing competition, an inevitable fact of life that need not spell its doom, but because computer technology is continuing to develop rapidly along several lines of thought. The Federal Government has an obligation to spur that development. This is not a new role. The computer industry has profited from government-industry-university cooperation from its inception, and that partnership has never ceased.

I take it from today's prepared testimony that government policy ought to proceed along two tracks that are analogous to developments within the industry. First, we have to make our current policy tools faster and more efficient, buying more supercomputers faster, putting more money into software development, better enforcing trade laws. Second, we have to experiment with some new policy architectures such as having all of the federal agencies work together, a mess of massive parallelism, if there ever was one, to create a national computer network.

I was also impressed with the observation of several witnesses about the greater use of supercomputers in Japan. We need to examine tax and other policies to see if we can encourage the use of these machines by industry. Philosophically, there appears to be little dispute about these undertakings. The White House Science Office has recommended similar steps, and these ideas are also incorporated into Senator Gore's comprehensive bill. The stumbling block is money. Frankly, we could pass Senator Gore's bill this afternoon and little would change. Because the Appropriations Committee would be unlikely to follow through. Already our existing programs such as the National Science Foundation Supercomputer Centers, a point of particular pride with this committee, have been suffering from inadequate funding.

In this budget atmosphere, our discussions here sometimes take on a weirdly theoretical air. They remind me of a joke that was supposedly making the rounds in Poland a few years ago.

A commisar goes up to a peasant and asks, "How many potatoes will you produce this year.

The peasant looks skyward and says, "With God's help, we will produce 1,000 potatoes.

The commisar looks at him reproachfully. "Comrade," he says, "you know there is no God."

"And you, Comrade," the peasant responds, "know there are no potatoes."

In this committee we say, with the help of more appropriations, we will create 5 new supercomputer programs but there are no additional appropriations.

So, in closing, I urge our witnesses and Science Committee members to make sure our colleagues on other committees, most particularly the Appropriations Committee, are as familiar with the Nation's critical needs in this area as we are.

Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Boehlert.

Are there other members who would like to make opening statements? Recognize the gentleman from North Carolina.

Mr. PRICE. Thank you, Mr. Chairman. I have no opening statement except to welcome our first witness. Senator Gore is an old friend. He, of course, is an acknowledged expert in a number of areas with which this committee deals, and we are very, very glad to have him open our hearings today. Welcome.

Senator GORE. Thank you.

Mr. WALGREN. The gentleman from California?

Mr. MINETA. Mr. Chairman, if I might, I would like to also welcome our very fine colleague, Senator Gore, and also commend you for your—for calling this hearing on the health of the U.S. computer industry.

As you have pointed out on many occasions, supercomputers are powerful tools in scientific and engineering research, and they enhance all aspects of the manufacturing process. One measure of the importance of these machines is their degree by use by Japanese industry, and a recent article in Nature reports that the private sector in Japan owns about two-thirds of the machines that are used in that country, and comparing that to the United States where only one-third of the machines are used by the private sector.

Now this finding foreshadows even stiffer competition between the United States and Japan in the future because supercomputers assist in designing high technology products. So, again in this field, as in many addressed by this committee, we spend our money on basic research to make the scientific and technological breakthroughs, but in Japan R&D funding is geared more to manufacturing and to commercialization of product.

Now I agree that more Federal agencies would benefit from the services provided by supercomputers; but, if we are to remain competitive with Japan, we must also increase the number of supercomputers used in private industry. We must make supercomputers more widely available if we are to increase both our com-

petitiveness in manufacturing and our ability to train future scientists and engineers. The ability of the United States to maintain its leadership position in the supercomputer industry will be a key to our own trade competitiveness during the 1990s and into the 21st century.

Mr. Chairman, again I want to thank you for calling this hearing. I look forward to hearing from our witnesses today, including some folks from our area, the Silicon Valley, from the Evans & Sutherland Computer Corporation, and I hope that this hearing will help us understand how we can help ensure the strength of the American supercomputer industry.

And thank you very much, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Mineta.

Well I want now to turn to Senator Gore and invite him to give us the view from the other side of the Capitol. As we said at the outset, we really do appreciate the role that you have played here in this committee, and particularly in this area. You were in the hand in the glove, literally, that has resulted in the OSTP report, which gives a good road map for where superconducting—supercomputing has to go in this country and are the proponent now of making that happen. And we want to be supportive in every way we can so that this capability is maximized for our country.

So welcome to the committee, Senator.

STATEMENT OF THE HONORABLE ALBERT GORE, A UNITED STATES SENATOR FROM THE STATE OF TENNESSEE

Senator GORE. Thank you very much, Mr. Chairman, and thank you so much for your kind words. And I appreciate the generous comments of others. I have many, many friends on this committee, and I remember with great affection my service on this committee. I learned a great deal here. I miss the committee, and it is a great pleasure to be back before you, even if it is on this side of the witness table.

When I first joined this committee 13 years ago, Cray research was in the process of installing its first supercomputer. At the time the word "supercomputer" was not in common use, and certainly it was not used at all in the daily newspapers. But that first machine has been succeeded by a string of ever faster, ever more powerful machines, until today we have supercomputers about a thousand times more powerful than that first machine, the first supercomputer that came out back around 1976.

Today, thousands of researchers in industry and academia are making regular use of these machines and new applications are being found daily. Mr. Chairman, you referred to many of these applications in your opening comments, and I am not going to deliver the full text of my prepared statement. I know it is the common practice here to include the prepared text in the printed record, so I will summarize my remarks. But suffice it to say on this point that the applications we can now identify represent only the tip of the iceberg. There will be thousands of applications we cannot now imagine.

The cliche is to say supercomputers will be the steam engine of the Information Age, playing a central role in advancing knowl-

edge and improving productivity. Some scientists have even gone so far as to say their capabilities represent the addition of a third branch of basic knowledge. In the past we have had deductive reasoning and inductive reasoning. Either you come up with a theory and you go out into the real world and test it against what you find there, or you go out in the real world and you collect facts, and then you go back and try to integrate those facts into an overarching explanation.

Supercomputing gives our civilization for the first time the ability to simulate alternative realities in such intricate detail as to make possible the investigation of new possibilities that were before now completely concealed to us. For example, pharmaceutical companies looking for new medicines can combine substances in supercomputer models a thousand times faster than it can be done in the laboratory. New molecules can be researched by chemists with dizzying speed. Wind tunnels can be created in computer models where they are impossible to create in reality, the new National Aerospace Plane, for example, if that ever gets off the ground. The wind tunnels we have in the real world just are inadequate for testing its capabilities, but supercomputers can simulate zero to mach 25 in a matter of seconds. Again, the capabilities are absolutely amazing, and the new developments will provide untold and unexpected benefits to our Nation.

Another point on this. These machines now cost about $20-$30 million. Within 5 years, machines with the same capabilities will probably be in the $500,000 range. So what we're thinking about should not be defined merely in terms of what is available today. As everyone who has looked at this field knows, the developments are taking place so rapidly that we have to struggle to keep up with them.

Typically, the hardware comes first and then the software. The third step in that process, unfortunately, is public policy. The software lags behind the hardware, and public policy typically lags far behind the software. This committee has been in the lead of making sure that our country does not follow that experience, have that experience where supercomputers are concerned.

You were generous in your comments, Mr. Chairman, about the Supercomputer Network Study Act. In truth, it was a Gore-Walgren bill, a combined initiative that I think has turned out to be extremely well received. I well remember the first meeting of the task force assigned that project. There was great skepticism in the room, a great reluctance to take the project seriously. But after only 2 hours of discussion there was general excitement around the room, and that group then undertook the task with gusto and determination and produced an excellent report, the recommendations of which are now largely embodied in the legislation that you and Congressman Boehlert referred to.

I believe that the single best thing we can do is expand the market for these machines here in the United States. There are a lot of ways to do that. The Federal Government has shown it can help to utilize the power of supercomputing with its own procurement policy, and the National Science Foundation's Supercomputer Centers represent a real success story. And this committee, of course, has played an absolutely critical role, members and staff.

The five NSF Centers have given industrial researchers a chance to see what supercomputers can do without having to actually purchase one. And, in many cases, companies that have used the supercomputers at the Centers for a year or two have found so many uses for them that they didn't realize existed, that they have then gone out to purchase one on their own. So, without these Centers, it is clear that fewer companies in the United States would be doing supercomputing today, and it is easy to see why Cray and other companies, IBM, have been willing to contribute so much to the Centers.

But we can do much more than increase the funding for the Centers. That should be done. With more funding, the Centers could provide more supercomputer time to more users and allow more U.S. companies to discover how they can improve their productivity and increase their profits.

In order to move beyond the additional funding for the Centers, I introduced S. 1067, the High Performance Computer Technology Act of 1989. I won't go into all the details, but it includes the titles on computer hardware, software, networking, and basic research and education. I did not want to focus just on the hardware, as sometimes happens, and forget about things like software and education. We need a balanced approach. And this committee has consistently encouraged and supported a balanced approach.

With regard to the network that is encompassed in this bill, I always use the analogy of the Interstate Highway System. We found that the explosion in the number of cars and trucks after World War II meant that our old two-lane road network was grossly inadequate to the flows of commerce that were then coming in the United States, and so the government took the lead in stimulating the creation of an interstate superhighway network, the benefits of which have been just incredible.

We need to expand our definition of infrastructure; and stop thinking of infrastructure just in terms of highways and bridges and water lines; and start thinking of infrastructure in terms of fiber optic cables and digital libraries and higher education, the supply of technicians and the like, because our Nation's ability to compete in the next century will depend upon the success we have in adapting to the information revolution.

The typical data highway now has about 56,000 bits of information flowing per second. These machines, when they communicate with each other, require data flows on the order of 3 billion bits per second. I mentioned already the decline in the cost of the machines themselves. That is because we are on about the sixth or seventh generation of supercomputers. But we are only on the second generation of network technology in this country. Yet the market forces are not pushing us quickly toward the large data flows that are necessary for the Nation to make maximum use of the capabilities of these new machines. So we need now an interstate network of information superhighways, 3 gigabits or more, connecting the major research centers, the major supercomputing centers, with the equivalent of interchanges where information-related businesses can cluster, software designers can down-load their products into a national network, so the Nation can use its inherent advantage of being a continent-sized market, an economic force to be reckoned

with in this world, and apply that force to the Nation's competitive effort in the Information Age.

There is tremendous support for this proposal. Incidentally, the other provisions also call for federal agencies to purchase prototypes and early production models of new supercomputers. It requires a review of federal export restrictions and procedures that may be putting American supercomputer manufacturers at a disadvantage in overseas markets.

One final word, Mr. Chairman. I, again, will elaborate in my prepared comments. But I am very pleased that the Administration—and I would say this partly in response to the opening remarks of Congressman Boehlert, my friend and the ranking Republican on this subcommittee—this is one of the few areas in which the Administration has requested an increase. There is a general recognition of how important this can be. Liberals and conservatives, Democrats and Republicans, have traditionally found it possible to agree on the idea of improvements to infrastructure. If we develop a new, more relevant, appropriate definition of what infrastructure means in the 1990s and the next century, then I think it will be pretty easy to build the kind of bipartisan support behind this kind of effort that it really deserves.

The funding, 1.75 billion over a 5-year period—that's not a lot. On average, a little over $300 million a year. The pay-back? Almost incalculable. The synergy, if you will, the mutually reinforcing benefits that come from different groups of researchers and different businesses using supercomputers being able to communicate with each other can produce in this Nation the same kind of impetus for economic development that the interstate highways produced for those aspects of commerce that relied on trucks and cars for their delivery and realization.

So I really think that it is the single most important step that the Federal Government could take to improve U.S. competitiveness in the Information Age. I think you will hear some similar comments from other witnesses that you have on your agenda for this hearing. We have on the Senate side a hearing that is being held in tandem with yours. That will be tomorrow afternoon and will focus on supercomputing and on how to build the information superhighways called for in S. 1067.

I want to acknowledge—in closing, Mr. Chairman, I want to acknowledge my debt to members of this committee and members of the staff of this committee who have consistently helped me to understand how the country should navigate this difficult course. I feel very fortunate to be a former member of this committee and have the personal friendships and relationships that allow me to learn from the insights that have been and are being developed here. And thank you, personally, Mr. Chairman, for your—the chance to work with you and for your generosity in asking me to testify today.

[The prepared statement of Hon. Albert Gore follows:]

REMARKS OF SENATOR ALBERT GORE

HOUSE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY

HEARING ON THE U.S. SUPERCOMPUTER INDUSTRY

TUESDAY, JUNE 20, 1989

Mr. Chairman, before beginning my formal remarks, I would like to thank you and the other members of the Subcommittee for giving me this chance to appear before you. As many of you remember from my days in the House, when I was a member of the Science Committee, I have long been interested in supercomputers and advanced computing of all kinds.

I'm glad to be back in this hearing room. I certainly spent a lot of time here in years past, although I was usually on the other side of the witness table. It is particularly good to come back to this hearing room to discuss this particular topic.

When I was first elected to the House in 1976, Cray Research was in the process of installing its first supercomputer. At the time the word "supercomputer" was not in common use and you certainly didn't see it used in the daily newspapers. That first Cray-1 has been succeeded by a string of ever-faster, ever more powerful machines, until today we have supercomputers about 1000 times more powerful than that first Cray thirteen years ago.

Today, thousands of researchers in industry and academia are making regular use of these machines and new applications are being found daily. In the universities, scientists are using supercomputer models to gain a better understanding of how man is affecting our planet and how the greenhouse effect may affect out global climate. Other researchers are using supercomputers to study the evolution of the universe, to design new drugs, even to understand the voting patterns of Congressmen.

In industry, engineers are using supercomputers instead of wind tunnels to test new aircraft designs. As many of you know, supercomputer models will be essential for development of NASA's National Aerospace Plane because no wind tunnel on earth operates at the speed at which NASP will fly. Luckily, supercomputer models can go from 0 to Mach 25 in seconds.

In the petroleum industry, geophysicists are using supercomputers to find oil. Chemical engineers are using them to improve how that oil is turned into useful products. New supercomputer applications are popping up in other fields as well.

The hardware is racing ahead and the software is moving quickly to take full advantage of these new machines. Here in Congress, we have to make sure that the policy does not lag too far behind. The new developments in computing can provide untold and unexpected benefits to our nation. As policymakers, it is our responsibility to maximize those benefits.

That is why I am very pleased that you decided to hold this hearing in order to examine the U.S. supercomputer industry and to try to determine what the Federal government can do to nurture this critical industry. The stakes are high. The world market for supercomputers is projected to be about two billions dollars next year. But even more important, supercomputers are a critical tool for improving America's competitiveness in a growing number of industries.

I suspect that your later witnesses will express concerns about whether the American supercomputer industry is threatened by the giant Japanese electronic companies. I share those concerns. The Japanese government and industry have targeted this market, and they have a lot of resources to spend. There are a lot of suggestions about what we should do to protect our supercomputer industry. I think by far the most effective action we can take is to expand the market for these machines here in the U.S. Cray and Thinkings Machines and other American firms sell good, competitive products. What they need is more customers to buy their products so they can use the profits to develop the next generation of supercomputers and stay ahead of the Japanese competition.

And of course, promoting supercomputing is not only good for the American supercomputer industry, it's good for all American industry. In a way, supercomputers are the electronic machine tools of the 1990's. Just as improved machine tools can stimulate productivity gains in hundreds of industries, improved supercomputers can dramatically improve

profits throughout U.S. industry. It is easy to see how productivity will increase if an engineer can use a supercomputer to run a program in one-tenth the time it used to take. But many of the productivity gains will come from new applications of computer technology that just weren't possible without supercomputers. New innovations in artificial intelligence, visualization technology, and database management will transform and streamline many jobs in the future.

So supercomputers can do wonders for American competitiveness -- provided they are put to good use. Unfortunately, there are indications that many U.S. industries are not taking full advantage of this new technology. According to the most recent figures I've seen, Japanese industry is ahead in the race to exploit the power of supercomputing. There are more supercomputers in use in Japanese firms than there are in U.S. firms, despite the fact that our economy is roughly twice the size of the Japanese economy. And they are in use in a broader range of industries. While in the U.S. most supercomputers are used for defense applications, for petroleum exploration, and in the aerospace industry, in Japan you can find supercomputers being used extensively in construction, in biotech research, in the service sector, and in dozens of other places.

The Federal government has shown that it can help American industry utilize the power of supercomputing. The National Science Foundation supercomputer centers are a case in point, a real success story. The five NSF centers have

given industrial researchers a chance to see what supercomputers can do, without having to spend several million dollars to buy one. In many cases, companies which have used the supercomputers at the NSF centers for a year or two have found so many uses for them that they have bought one of their own. Without the centers it is clear that fewer U.S. firms would be doing supercomputing today. It is easy to see why Cray and IBM have been willing to contribute so much to the centers; they are probably the best advertisements for supercomputers anywhere.

However, we can do more. With more funding, the centers could provide more supercomputer time to more users. Many more firms could discover how to increase profits and productivity with supercomputing.

And there are many other ways in which the Federal government can promote supercomputing. That is why last month, I introduced S. 1067, the National High-performance Computer Technology Act of 1989. It is a comprehensive bill aimed at enhancing the development and use of all aspects of advanced computing. It includes titles on computer hardware, software, networking, and basic research and education. I did not want to focus just on the hardware, as so often happens, and forget about things like software and education. We need a balanced approach.

If you're going to win a stock car race, you can't focus all your effort on your car. It might be the fastest thing on wheels, but you also need a good driver with experience and know-how and you need the right fuel to make the car go.

Likewise in the supercomputer race, you want a fast machine, but you also need talented people who know how to use it and the right software to maximize its performance.

My bill also addresses the need for "information superhighways", high-speed computer networks to link researchers and supercomputers throughout the country. The bill calls for NSF to establish a 3-gigabit computer network by 1996 and authorizes four hundred million dollars over the next five years to pay for it. Such a network could transmit three billion bits of data per second. In other words, it could send 100,000 single-spaced typewritten pages in a single second. That's an entire year's worth of the Congressional Record! More importantly, it can transmit video images and movies which will allow researchers to assimilate and understand hundreds of pages of data in a few minutes.

Today thousands of researchers use NSFNET, which NSF built to link the five supercomputer centers to each other and hundreds of universities. NSFNET operates at 1.5 megabits, or millions of bits of data per second. The 3-gigabit National Research and Education Network I am calling for would be 2000 times faster and would serve more than a million researchers nationwide.

We need high-speed, gigabit networks to take full advantage of the power of supercomputers. Supercomputers can produce hundreds of millions of bits of data per second. Clearly long-distance networks like NSFNET can not handle all that data. Today, if you want to use the full power of a

supercomputer, you can't be more than a few hundred yards from it. The National Research and Education Network will provide supercomputing power to anyone with access to the network. A researcher at a small college in the hills of eastern Tennessee will have the same supercomputing power as researchers at institutions like Harvard and MIT which can afford supercomputers of their own.

In addition, the network will bring supercomputing to industry. It will allow small businesses a chance to use these machines which they could never afford to buy. While a small company might not need a ten-million-dollar supercomputer and certainly couldn't afford one, with the network it could rent time on someone else's machine in order to test new products or develop improved manufacturing techniques.

A national supercomputer network will certainly speed up the spread of supercomputing into American industry. And it will expand the market for American supercomputers many-fold. It will allow companies to experiment with supercomputers without buying one. Undoubtedly, many companies will end up buying a machine of their own, just like many of the industrial users of the NSF centers have.

The National High-performance Computing Technology Act also includes other provisions which will promote the use of supercomputing, both in government and industry. Under Title IV on computer systems, it calls for Federal agencies to purchase prototype and early production models of new supercomputers. When a company is developing a new machine

it has to find ways to test the system and the most realistic test you can provide is to ask real, honest-to-God researchers to use it. The first Cray-1 was sold to the Los Alamos Labs and researchers there made invaluable suggestions for improvements in the software which were incorporated into later versions of the machines. Unfortunately, it would be very difficult for Cray to make such an arrangement today due to new government procurement regulations. These regulations require that there be two competitive bids for almost all government contracts. While that makes sense for procurements of things like paper towels or typewriters, I'm not sure that such a requirement makes sense when an agency wants to buy a one-of-a-kind machine that's only made by one manufacturer.

Likewise, my bill requires a review of Federal export restriction and procedures which may be putting American supercomputer manufacturers at a disadvantage in overseas market. We must make sure that our regulations keep pace with this changing technology.

I hope that my colleagues here on the Science Committee will join me in helping the Federal government do more to promote the development and use of supercomputers and computer networks. There is widespread recognition of the fact that we need to do more, but turning that awareness into action will require that many different groups work together toward that common goal. It will require that government work with industry; that Democrats work with Republicans; and that the Congress work with the executive branch. The

different agencies will have to work together and the House will have to work closely with the Senate. We have done so in the past. In 1986, I introduced legislation requiring that the Office of Science and Technology Policy explore how fiber optic networks could link computers in a "information superhighway system". With your help, Mr. Chairman, and with the cooperation of this committee, that legislation was sent on to the President. The resulting OSTP report outlined, in general terms, an ambitious high-performance computing initiative. I worked with the agencies and built on that report to produce S. 1067, which will set that initiative in motion.

Tomorrow afternoon, I will chair a Senate Science Subcommittee hearing on that legislation. That hearing will focus on supercomputing and on how to build the information superhighways called for in the bill. It is my hope that S. 1067 will help find answers to many of the problems and challenges you will hear about this afternoon.

I hope that my colleagues here will support this legislation so that the U.S. supercomputer industry can remain healthy and so that all of American industry can retain its competitive edge.

Thanks again for giving me this chance to appear before you. I would be happy to answer any questions you might have.

Mr. WALGREN. Well, thank you very much for such a good push at the outset, and we will all benefit from that. You will be having your hearings this week, and we will have further hearings in July on the Office of Science and Technology Policy report. And I couldn't help but notice in their estimate of what supplemental funding would be needed to pursue this area, in the range of recommendations they make, which is a broad-based range as well, that they are certainly within the ballpark—

Senator GORE. Yes.

Mr. WALGREN. —of the numbers that you have mentioned today for your own legislation. So we look forward to trying to develop that on this side of the House with you on the other.

Senator GORE. If I could add one small point, one of the reasons the cost is so low, Congressman Boehlert, is that when the long distance market was opened up to competition, MCI, Sprint, and a dozen smaller, often regional companies installed very large volumes of fiber optic cables. The cables have the inherent capacity to carry much larger volumes of data than they are now used to carry. The economics of cable installation, fiber optic installation, make it attractive to install large redundancies in basic capacity. What's missing are the switches, the software, the so-called last mile. And so when it comes to the point of actually installing this network and putting it into place, if you use the superhighway analogy, the asphalt is there. You need the entrance ramps and the exit ramps and the signs that tell you which route goes where for the optical signals to get to their proper destination. That turns out to reduce the cost dramatically, and so that is the reason the cost is so low for an achievement that would have such large benefits.

Thank you, Mr. Chairman.

Mr. WALGREN. Other members like to raise—Mr. Boehlert?

Mr. BOEHLERT. Senator, I want to thank you for your particularly eloquent statement. It's good to have you back home here. We're kindred spirits.

I hope no one misinterpreted my opening statement, because I have long been a strong supporter, as this Subcommittee has, of the whole supercomputer effort. As a matter of fact, it was launched in this very Subcommittee. And, if anything, we're accused on occasion of being overly generous.

And I would thank you on behalf of the administration for your kind words about what it is doing. The problem is not with the administration, not with this Committee, it is our colleagues on the Appropriation Committee, which once again, second year in a row, have cut the NSF funding request of the administration, of this conservative administration. So we have got to work very hard to convince our colleagues on the Appropriations Committee that they have got to be as responsive to the problem and the issue as we have.

I have just one question, a little bit different. Everybody talks about how much is this going to cost. My question of you, and I think you have given it a lot of thought, what would be the cost of not doing what we're suggesting here today?

Senator GORE. Well, the cost of not doing it would be the loss of, perhaps, the single most important new technology that will have dramatic commercial implications in the 21st century. Everyone is

familiar, and particularly members of this committee are familiar with the litany of horror stories that includes the VCR, invented here and then produced overseas. There is a long list.

Supercomputers were innovated here, and we now have the dominant position in manufacturing supercomputers. But, as some of the witnesses will tell you, they are starting to sell a lot more machines overseas than they are to private businesses here in the United States, and the Japanese manufacturers are making dramatic strides in catching up with the U.S. leaders. We can pretend that we don't need to do anything, but I think the logical outcome of that choice would be that U.S. leadership would be lost. And we would be purchasing supercomputers from overseas in the early part of the next century. We can't afford to have that happen with the technology that is this important. This is a key. It is like the steam engine was to the Industrial Age. So the cost of not doing it would be literally incalculable.

Mr. BOEHLERT. We agree with you on that and we are partners in this century. Thank you very much.

Senator GORE. Thank you.

Mr. WALGREN. Gentleman from North Carolina.

Mr. PRICE. Thank you, Mr. Chairman.

Senator, I think that was a fine statement. I commend you for it. As you know, worldwide sales of supercomputers in 1988 was about a billion dollars, which is a fairly small market, relatively speaking. There are those who say that the important thing is not who manufactures the supercomputers, but rather that we ensure scientists and engineers are trained to use them and that industry begins to take maximum advantage of them. What do you say to that argument? Does it matter where supercomputers are made?

Senator GORE. Well, first of all, I essentially agree that the crucial question is how you use them and who uses them and who puts them to best use. This network that has been proposed would make it possible for researchers and private corporations in the United States to make the best use of supercomputing capacity.

Now, if the market here in the United States grows by leaps and bounds due to that synergy I've referred to coming from the network, then I think that gives us a better chance to consolidate our lead in manufacturing here in the United States. Both are important. We would like to build the machines here, and we would also like to be the world leaders in using them simply because their power for enhancing productivity is so great that it will lead to improvements in the balance of trade, improvements in our ability to reach our overall economic goals.

Mr. PRICE. You have information about how willing U.S. companies have been to utilize the supercomputers, again relatively speaking? What are the main factors? Do we know what the main factors are which influence whether or not a company will begin to explore these capabilities?

You talk about the NSF Centers as encouraging this kind of use. Do we have any comparative international picture on that, about how quickly our companies are picking up on these applications?

Senator GORE. We've been very slow on the uptake. Very slow. Some people say the main limiting factor is a shortage of trained personnel who are familiar with these machines, their capabilities

and how they can be applied to the operations of the company that is considering making use of such a machine. One of the things we have got to address is the educational system which turns out people who are capable of using these machines.

Mr. PRICE. And that is an emphasis in your legislation.

Senator GORE. Absolutely. And with universities connected to this network, even smaller universities will have access through work stations to supercomputing capacity. And when students get interested in these machines during their undergraduate or graduate years, then it greatly increases the likelihood of them going into that specialty, acquiring the knowledge they need, and then leaving the university to take the new positions that are opening up as companies become aware of what these machines can do.

And you know, if the price does indeed come down to the $500,000 level, virtually every large to medium-size corporation worldwide is going to have to at least consider the implications of a competitor having this capacity and them not.

Mr. PRICE. So you see education and training as an essential element—

Senator GORE. Absolutely.

Mr. PRICE. —in encouraging widespread use.

How important a component of existing NSF programs are education and training?

Senator GORE. Well, we could do more, and we should be doing more. I take a slightly different view of this question. I agree totally with those who say education is the key to it, but I genuinely believe that the creation of this nationwide network and the broader installation of lower capacity fiber optic cables to all parts of this country will create an environment where work stations are common in homes and even small businesses with access to supercomputing capability being very, very widespread.

It is sort of like, once the Interstate Highway System existed, then a college student in California who lived in North Carolina would be more likely to buy a car and drive back and forth instead of taking the bus. Once that network for supercomputing is in place, you are going to have a lot more people gaining access to the capability, developing an interest in it. That will lead to more people getting training and more purchases of machines.

Mr. PRICE. Thank you. Thank you, Mr. Chairman.

Mr. WALGREN. Any other comments? Mrs. Morella?

Mrs. MORELLA. I just simply want to thank Senator Gore for coming here. I think his presence and his statement indicates his commitment to the U.S. supercomputer industry. I just appreciate it.

Senator GORE. Thank you.

Mrs. MORELLA. Thanks.

Mr. WALGREN. The gentleman from California?

Mr. MINETA. Mr. Chairman, if I could ask, recognizing you want to get to the witnesses—like to get to the other witnesses, I would like to ask very quickly about—I'm sorry I'm not familiar with your bill. Does it use the resources, the financial resources to buy the computers for Federal Government, at the Federal Government use, to be networked by the private sector, or is there some kind of incentive to get these computers back out into the private sector?

Senator GORE. Well, it does several things. One provision of the bill does address government procurement policy and lead to the actual purchase of some of the new supercomputers by government agencies that have a need for that capacity. For example, in California there is a great deal of global climate research. It's done on supercomputers. In Colorado the same thing takes place, and at Cornell, for example. If one of those researchers wants to communicate with another one about what the model shows, they now have to download the model into a disk, take it with themselves, get on a plane and fly, and then upload it and talk. The information link will make it possible for them to communicate directly.

When a new supercomputer comes out, this legislation will make it more likely that such Centers would purchase new prototypes here in the United States when they have the need for more capacity. So it does several things, but part of it is aimed at procurement.

That is not the biggest expense, though. That's not the main part of it, but it is an essential part.

Mr. MINETA. Very quickly, on another part of it, I come from, as you very well know, Silicon Valley. To what extent would you say that the semiconductor industry is going to be able to keep pace with what your hopes are in terms of the aspirations for that industry? I mean, we can't even produce 256K DRAMS, and I'm just wondering whether or not we're now going to be dependent on someone else being at the throttle of what we are even going to be doing.

Senator GORE. Well, already Cray has to purchase some of its key semiconductors from, I think, Fujitsu in Japan, and that's something that should raise a warning flag. And this effort should be seen as a more comprehensive plan for positioning the United States for success in the information revolution. The DRAM industry, for example, is related to the whole question of HDTV.

Mr. MINETA. I was just going to raise that issue.

Senator GORE. If, in fact, 50 percent of the DRAMs sold globally in the year 2000 are going to be embodied in these new machines, then it's important who manufactures those machines, who starts up the learning curve, who develops the economies of scale, and who has the capacity to maybe hold out other new entrants into the marketplace. And so we should also pay attention to the related problems of HDTV. How do you get fiber optic cable to the home, and what implications does that have for cable television, et cetera?

Mr. MINETA. Just thinking about the demands that are being placed on the budget, just from this Science, Space, and Technology Committee in terms of HDTV, Superconducting Supercollider, Space Station, now 1.75 billion in your bill—

Senator GORE. Over 5 years.

Mr. MINETA. —over a 5-year period. You still layer that on top of—

Senator GORE. Yes.

Mr. MINETA. —other requests that we all have. And you wonder, you know, how do we separate, how—

Senator GORE. Well, I would set the priorities as follows. I think the network ought to be the number one priority in this area. I

genuinely do. I think that Sematech ought to be right up there, a successful—a continuation of what is emerging with some success as a key project for the United States. And the Armed Services Committees have a role in that also with DARPA. But I think that those two ought to be right up there.

Now what you do on HDTV, I have my views on what ought to be done. I have asked for the Administration to report back within 90 days with a comprehensive plan and the details of what ought to be addressed or spelled out in the legislation. But, frankly, I think that's third on the list after these first two items. I think the network ought to be number one.

Mr. MINETA. Again, thank you very much for your testimony—

Senator GORE. Thank you.

Mr. MINETA. —and for your leadership. Thank you very much, Mr. Chairman.

Mr. WALGREN. Thank you very much, Mr. Mineta.

Well, thank you again for coming over today. And I know I want to say for all of us when you run for President you have a tremendous number of personal friends or people who feel they really are your personal friends. And I know that everyone in this room is very grateful that your boy is making such a wonderful recovery from the accident he had several months ago.

Senator GORE. Well, I appreciate that about my son very, very much, Mr. Chairman. And it's true I used to be the next President of the United States.

[Laughter.]

Senator GORE. But with regard to anything—you know, I don't—I didn't expect you to ask that question.

Mr. WALGREN. Okay.

Senator GORE. Thank you very much, Mr. Chairman.

Mr. WALGREN. Thanks for coming over.

Mr. WALGREN. The first panel that we have today, we welcome Dr. David Kuck, Director of the Center for Supercomputing Research and Development at the University of Illinois at Champaign-Urbana, and Dr. Fred W. Weingarten, Senior Associate in the Communications and Information Technologies Program at the Office of Technology Assessment.

Gentlemen, if you would come forward. And, as with all of the witnesses today, your written statements will be made part of the record and will be reproduced without more, and you can feel free to pick and choose and highlight in whatever way you would like to underscore points for the verbal part of the transcript and in ways that would bring them out in the best possible way.

Let me ask Mr. Price if he would take the chair for 10 or 15 minutes or so, and I will be back. But we appreciate your being here, and we look forward to your testimony.

Mr. BOEHLERT. Mr. Chairman, before you leave, I would like to ask our first panel if either one of them are running for anything. The chairman is in an expansive mood today.

Dr. KUCK. Not at this moment.

Mr. PRICE. [presiding] Dr. Kuck, we are glad to have you here, and will ask you to proceed.

STATEMENTS OF DAVID J. KUCK, PH.D., DIRECTOR, CENTER FOR SUPERCOMPUTING RESEARCH AND DEVELOPMENT, UNIVERSITY OF ILLINOIS AT CHAMPAIGN-URBANA, URBANA, ILLINOIS; AND FRED W. WEINGARTEN, PH.D., SENIOR ASSOCIATE, COMMUNICATIONS AND INFORMATION TECHNOLOGIES PROGRAM, OFFICE OF TECHNOLOGY ASSESSMENT, WASHINGTON, D.C.

Dr. KUCK. I thank you for the invitation. I'd like to—I submitted some written material, and I'd like to just summarize the summary that's in there briefly. I'd like to talk about the current situation, and then how we got to this situation and some thoughts about the future.

We have been using electronic computers for 40 years; and, by the early part of this decade, we entered a problem-solving phase of the sequential computing era in the sense that you could buy hardware and software that does exactly what you want it to, it's easy to use, and doesn't cost very much money.

Over the 40 years that we've had electronic computers, there's been a factor of 10 increase in speed about every 7 years. In the early part of this decade, something unusual happened. We entered what I think of as a parallel computing era. Every computer manufacturer, from supercomputers down to work stations, started to introduce parallel hardware. The reason for that is that the fastest machines' clock speeds have been slowing down. From the Cray I to the Cray II, there was a 3 times clock speed increase over a decade or something like 20 percent of the speed increases that we had seen in the past. So everybody saw that we needed to move in a parallel direction. These machines have been introduced across the board, but software isn't really there.

How do we get something faster? There are two ways: one is faster technology; the other one is the exploitation of parallel processing, which many of the companies that you are going to hear from today have been working in.

I would like to add, on the Japanese front and on the performance front, that I don't believe you can tell the difference between the speed of a Cray and the speed of the fastest Japanese machines. In other words, it is very difficult to talk about what speed is for supercomputers, but on a mix of problems you are as likely to have a Japanese machine or a Cray come out fastest. So I think the issue about who has got the fastest machine is a very cloudy one at this moment.

How did we get to this point? Well, performance understanding is extremely difficult. People who design machines know what the peak speed is going to be, but they don't really have any idea how it's going to perform on one computation or another. It's not until the hardware is all put together, system software, applications software has been put on, that one can really understand what one has, and then, in fact, we're now in a situation of what I think of as unstable performance. That is, the faster the machine is, the more likely there is to be a big variation in the running time from the slowest to the fastest computations. So, on Crays or NECs or other Japanese machines today, there may be a factor of 50 between one computation and the next, whereas on a minicomputer or a mainframe that factor might be two or three. A great deal of

the infatuation with supercomputing has to do with people who are going from vaxes or mainframes to very fast peak—very high speed performances on supercomputers.

This country has been very innovative in architecture. I mentioned parallel machines across the board in the last decade. We haven't done a very good job of making complete systems. By that I mean software included with the hardware. Start-up companies have a very short time frame, two or three years to get something into the marketplace. Big companies tend to avoid this area or do research in very focused parts of the area. So the integrated systems are not there. The high performance, high peak performance, innovative systems do exist, but they're not complete with software.

State money and Federal money has been very good for infrastructure. There's something like 30 supercomputers, or supercomputer-class machines, in American universities today, the NSF Centers, some from the DOE, and a lot supported by the States themselves. But almost no money is being spent on research in this area. That infrastructure money does not go to support how do we get better supercomputer architecture, how do we get better software, et cetera. That's money to support the use of these machines by scientists and engineers, which is extremely important.

Another way we got into the state we're in, I believe, is that there isn't much cooperation between American companies. There hasn't been traditionally. Everybody wants to own and develop everything themself, hardware and software. There's a noticeable change in that in the last few years, but still there's a lot of going it alone. That has led in the past to lack of portability between machines. At the language and operating system level, some of those problems are being fixed. On the other hand, when you have such a range of architectures that we have now, performance portability is almost impossible. You tune and work very hard to get your code running on the machine you happen to have. If you want to move it to another machine, another run at that whole subject has to be made.

What about the future? Well, being an academic person, you expect me to say that we need more money. I think some money is needed. I don't think it is a whole lot of money. There are very few places doing systemwide research in this area; and, so if even a fraction of what we spent on infrastructure was spent on R&D at the system level, I think good things would happen.

Universities have been very bad about training people in computational science and engineering, as Senator Gore referred to that subject. There is a new way of thinking about doing science and engineering. Unfortunately, today people get trained in ad hoc ways. We've started a new program at Illinois, and some others are, but we're not in very good shape. I think some kind of cooperation between universities and industry in particular would be important, possibly with some government involvement. Two examples are the Japanese MITI, which you all know about, or maybe a more interesting domestic model would be the Semiconductor Research Corporation, which brings university researchers and semiconductor companies together. And they mix it up with respect to problems and with respect to solutions to those problems.

It's very important to realize, however, in this field that it's not just hardware and software, it's users and how those things are going to perform when they're built. So a very broad mixing is needed.

Finally, the hardest thing we need is some ideas developed on three areas. Packaging, how do you configure these machines to make them perform the way you want them to? Performance studies to be able to predict what the performance is going to be and then to understand what you have, measure the performance. It's not really being done very broadly at this moment. And finally, programmability. They should be as easy to use as your Mac or your IBM PC are today. And I think they can be in the next decade.

A couple of final remarks. Parallel processing has the ability to make us technology independent. That is, instead of gates and devices that are faster and faster and faster, by replicating those things, using them in—a multiplicity of them—you can break away from technology barriers. You can also break away from the suppliers of those technologies.

Parallel processing offers the potential of cost-effective systems, ideas that range from work stations to supercomputers. That is, the same ideas can be used across the spectrum, and we talk about scalable high performance systems. So little machines on your desk, big machines in some central place that more or less work in the same way.

With that I'll stop.

[The prepared statement of Dr. Kuck follows:]

WRITTEN STATEMENT

to

HOUSE SUBCOMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

June 20, 1989

by

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Background

Interest in high-performance computing has risen substantially in the past few years. One reason is that supercomputers push technology and lead to a trickle-down effect that enriches many other computer systems. Another reason is the insatiable demands that scientific and engineering users have for faster computation. The DOE and NSF have for some time made supercomputers available on networks and these facilities have steadily increased in their usefulness to a wide community. Proof of the success of the programs may be found in the fact that about 30 U.S. universities have now purchased high-performance computers for their users.

While access is now broadly available, many users find the systems difficult to program effectively. Indeed, even experts find the systems' performance unstable in that from one computation to the next, there may be one or two orders of magnitude in performance difference. To redress this situation, much work remains in studying the performance and then in improving the architecture, system software and application software of these machines.

Between the late 1940's and the late 1970's, the electronic computer rose from a few university ideas to a giant industrial force. The *von Neumann computing era* began in the late 1940's. The period through the 1970's was a tool building phase of the von Neumann era, in which cache memory, virtual memory, compilers, operating systems, applications libraries, user-friendly interfaces, etc. were constructed. By the 1980's, low cost, easy-to-use problem solving systems were available for bank clerks, architects, school children, etc. as a result of this tool building. The problem solving phase of the von Neumann computing era now has an effect on everyday life in many parts of the world.

This von Neumann computing era led to a broad and intense level of research in computer systems, per se, in the 60's and 70's, when many universities introduced Computer Science and Computer Engineering departments. By the late 70's, many of the important earlier research areas seemed played out as vital wide-interest subjects in Computer Science and Computer Engineering — numerical analysis, compilers, and computer architecture seemed to be serving industry well — and new areas of interest arose in these academic departments.

In the early 1980's, a change occurred, and companies began introducing parallel computer systems. Today parallelism exists from the level of workstations and minicomputers up to supercomputers. These systems are more difficult to exploit than the previous vector machines, and many issues about performance are poorly understood. The fastest machines widely available today are Hitachi, NEC, Fujitsu and Cray supercomputers. The explosive increase in new supercomputer users has led to a broadly held feeling that these machines offer tremendous increases in computational capability. But in reality [NRC89] this perception is largely due to the fact that a decade ago many of these users were using a minicomputer that was two or more orders of magnitude slower than a Cray.

The *parallel computing era* has roots that go back many years, but the era really began in the first half of the 1980's with the introduction by manufacturers of parallel machines in many segments of the computer market. Supercomputers, mainframes, minisupercomputers, superminicomputers, and even workstations all have parallel processing capabilities today. We are now in the midst of the hardware tool–building phase of the parallel computing era, and the software tool–building phase is just beginning; it is similar to the von Neumann era in the late 1950's. The 1990's will be a decade of intense parallel processing software tool building, and perhaps by 2000 we will have reached the parallel problem solving phase.

There is a long–standing tradition in the computer industry to ship hardware systems that have weak software. This became impossible in the problem–solving phase of the von Neumann era — bank clerks, architects and school children simply cannot write their own software. For example, spreadsheet software must be simple to use and do just what users want it to. In the 1980's, speed and reliability cannot even be issues with mass–market software.

Speed has been a major factor in forcing us to enter the parallel processing hardware phase of what appears to be a new parallel computing era. There has been a 10 times growth per seven years over the 40–year history of the von Neumann era. But, for example, Cray clock speeds have increased at only 20% of that rate — 3X in 10 years from the Cray 1 to the Cray 2. Furthermore, faster technology implies more complex computer manufacturing techniques and hence more cost. Thus parallelism has a broad appeal among designers of computers. The promise of parallelism is the speedup of computations by a factor proportional to the number of processors used, without having to use the fastest (and hence most expensive) available technology.

Software is the problem with this approach. Today, parallel processing software does not exist in nearly the quality or breadth that it does for von Neumann era machines. And now, much more than in the von Neumann era, software is necessary to deliver the performance potential of parallel machines. In the von Neumann era, compilers, operating systems, and applications packages were largely provided to make hardware systems easier to use. In fact, people were willing to give up performance in return for software that enabled new classes of users on von Neumann era machines. Now, such software must provide basic performance; it must help the user exploit the system.

Exacerbating the situation is the performance instability of parallel machines. In the von Neumann era, on a given machine there might be factors of 2 to 3 or even 5 to 10 in some instances between good and bad performance in solving some problem. In the parallel processing era, however, the factors can easily be 50 to 100, and as massive parallelism is used the factor can rise by several more orders of magnitude. This is forcing a change in the basic nature of how software must be provided for parallel machines. To date, most systems have fewer than 10 processors so the issues are relatively minor. Many have vector processors, which further obscures the basic problem. Nevertheless, the problem is here today — very few parallel machines are being used in parallel mode for production computations — and the problem is increasing in severity. Industrial

designers, in fact, seem to see no hope for changing the instability situation. [PeZo89]

In short, a number of architectural and software problems remain to be solved. Who will solve these problems and carry us through a new parallel computation era that seems inevitable, to continue the momentum in scientific and engineering computation that the von Neumann era launched?

Computer companies try, but they are still largely hardware oriented and make time-to-market based decisions. Ease of use, or performance obtainable, are not as important in their advertising literature as a faster clock speed, more processors or more memory. Universities are now largely ill-equipped to work on these problems. The eager university users of supercomputers today seldom have any idea of what is required to exploit the systems — they are accustomed to a minicomputer or standard mainframe where every job is performed at about the same rate of speed. The major funding that is now in place to provide user access to supercomputing has done nothing to help solve these problems. Computer Science and Computer Engineering faculty have turned their attention to new areas including VLSI, operating systems, artificial intelligence, and theory of computation. The number of large university projects aimed at software or hardware for parallel processing or supercomputing has declined in recent years and support is dwindling.

Computational Science and Engineering (CSE) university programs are urgently needed to train students and help develop the parallel computation era. CSE research and teaching programs would deal with the computational aspects of science and engineering problems as well as apply science and engineering to the modern computational process. Funding for CSE should come partly from federal agencies and partly from industry — both computer manufacturers and users. If a Semiconductor Research Corporation-style organization could be formed, in addition to channeling research money into universities, relevant problems and solutions could be exchanged between industry and academia. To remain world leaders in the design, manufacture and use of high-performance computers, the educational content and research funding of our university programs must change soon.

The von Neumann and parallel computing eras will be remembered as tool-building eras. Users are now concerned with network access, program restructuring, parallel debugging, and visualization techniques. We are moving toward the problem-solving era that will provide an easily accessible network of supercomputers, departmental minisupercomputers and desktop interactive visual stations on which users can spend their time solving the problems of their disciplines using software systems that contain integrated numerical and symbolic processing. To have entered the problem-solving era should be a national goal for the year 2000.

<u>Summary</u>

A. The current situation is that:

1. High performance computers are too slow and the rate of speed increase is dropping.

2. Hardware device technology breakthroughs could remedy this, but no obvious candidates exist.

3. Parallel processing can provide large speed increases without faster hardware technology. Architecture, packaging, compilers and applications software are the keys, and many innovative systems have been built, but much work is needed in these areas.

4. Japanese supercomputers deliver performance that is comparable to (and sometimes faster) than American supercomputers. Currently they do this without the use of parallel processing, rather using fast circuits and good compilers. Parallel Japanese systems are expected in 1990.

B. How did we reach this situation?

1. Delivered performance of parallel machines has wide variations, is hard to predict, and has been little studied, so designers frequently do not know how machines will perform over a range of computations. Peak performance is often quoted, but such numbers are unattainable in real applications and irrelevant in making predictions about particular applications.

2. Startup companies spend most of their money on hardware with 2 to 3-year product plans. Large company R & D money is spent on focussed topics. Long term, system-level research and development, including software, is lacking in the U.S.

3. American companies have produced a wide range of hardware architectures, but few have the expertise to produce good software. I see little point to this diversity (including massive parallelism) unless complete systems including high-performance, easy-to-use software are produced. For the long run, however, these diverse systems may be regarded as valuable data points.

4. State and federal money has been spent on infrastructure for supercomputing, i.e., purchase of supercomputers and networking of systems, but this does little to advance our understanding or development of high performance computing, per se.

5. American computer companies have little interest in cooperation with one another in these areas. Most companies have had intense desires to develop and own as much technology as possible. This has shifted at the hardware level and is shifting at the software level, as system manufacturers realize the overwhelming complexity of the problem.

6. Diversity of architectures and languages leads to lack of compatability of applications software. Compiler implementation differences between manufacturers have long made porting applications somewhat annoying. Now, the architectural myriad makes performance portability of applications absolutely impossible, generally, for tuned programs.

C. Future needs include:

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1. Money for research and development in parallel and supercomputing systems.
2. Trained people, of which there are very, very few today. Computational Science and Engineering programs in universities are desperately needed to work and teach in these areas.
3. Cooperation between industry, academia and government. MITI and SRC are examples of enabling organizations that have been effective, although may not be ideal role models here. The cooperation must include a range of people from system designers to end users, as well.
4. New ideas about packaging, performance, and programming. New ideas are needed that allow us to design and manufacture computer systems that deliver predictable, high performance and are very easy to use. This would lead to qualitatively different uses of computers, and would free up engineers and scientists to work in their own disciplines rather than be concerned about computing issues for major parts of their professional lives.

In summary, it must be realised that solving these parallel processing problems unlocks new cost–effectiveness approaches to building families of computers that range from parallel desk–top workstations to the fastest supercomputers.

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Biographical Sketch

DAVID J. KUCK

David J. Kuck is Director of the Center for Supercomputing Research and Development (CSRD) at the University of Illinois. He founded CSRD 5 years ago to develop hardware and software for parallel supercomputing. CSRD employs 100 people, has a $6M per year budget and is finishing the Cedar parallel processor. Previously he has contributed significantly to the hardware and software design of several parallel computing systems: Illiac IV (1960's), Burroughs Scientific Processor (1970's), Alliant FX/8 (1980's). He serves on the Boards of Directors or technical advisory boards of several parallel computing companies today. He was a founder in 1979 of Kuck and Associates, Inc., which today provides vector and parallel processing software for a number of computer systems ranging from workstations to supercomputers.

Mr. PRICE. Thank you. We'll have a chance to develop some of these themes in a moment.

Dr. Weingarten, we'll now turn to you.

Dr. WEINGARTEN. Thank you. Thank you, Mr. Chairman.

If I may, I'd like to summarize briefly some of the few key points in my testimony. In addition to being a Senior Associate at OTA, I'm also the project director of a study on research use of communications and new computer technologies in which this committee, in fact, is a principal requester, and it's based on this work that my testimony will be developed. Also, in the room are Mrs. Lisa Heinz and Ms. Liz Miller, who are also analysts, and they assisted me with developing the testimony.

I would like to describe, just briefly, where that project is going and add a couple of caveats on my testimony. This testimony will be a brief summary based on an interim report that will be coming out in a few weeks and delivered to the committee on the state of supercomputer centers and supercomputing and networking in science. Later in the summer, we're going to be looking more closely at some issues of supercomputer industry development and future technological development because it turns out to be an important issue when one asks about the stakes for the scientific research community, which is the main focus of our study. And the final report will be out next year, about a year from now, in fact.

So I would like to emphasize that we are not doing a trade study, and we're not looking specifically—it's not an industry structure study. We are taking the perspective of the need for this technology by the research community and the stakes of the U.S. economy and society in that use.

I'd like to develop four points that I think are at least implicit, if not explicit, in the written testimony. In the first place, I was tempted to start out this testimony by saying that there was no such thing as a supercomputer industry, except that I knew that Mr. Rollwagen would be sitting behind me and might get a little agitated at that statement. But the purpose of making that statement is that this is an industry whose boundaries is very difficult to draw, and it is not a simple problem of drawing boundaries. It is a complex one because, as one moves out, the entire character of the industry changes.

To take the most narrow definition, there is only one firm making supercomputers now in the United States and putting them on the market. There are a couple others that are developing systems and will have them along in the future. But right now there is simply one, Cray Research. It is a $750 million a year, roughly speaking, firm, serving about a billion dollar market worldwide. That is one type of industry.

If one moves out just slightly into what we call vector processors, one encompasses a firm whose annual revenues are closer to $60 billion a year, a U.S. firm. The market itself is estimated at about $100 million. Vector processors are additional pieces of hardware that attach onto mainframe, very large mainframe computers, and are produced principally by IBM. And, while some people in the field argue whether or not that in fact is a supercomputer, one of the five NSF National Supercomputer Centers is based on IBM technology, and there are over 30 universities and State centers

that operate such systems and call themselves supercomputer centers. So somehow some people define themselves to be supercomputers.

Most broadly, one can define this industry as encompassing what we call the mini-supercomputers or the radical architectures, the new experimental architectures. One of our consultants has estimated that there may—are as many as 300 firms in the U.S., small start-up companies, claiming that they make such machines or are planning to market such machines, of which he estimates maybe a hundred are really mini-supercomputers and only a half dozen or so, maybe twice as many, are seriously in the market. They, in turn, are serving what is estimated roughly as a $200 to $300 million market worldwide.

So, as one expands the definition, the size of the market doesn't change very much. Goes from about a billion to about a billion four, billion five. But the character of the industry and the U.S. position in this industry changes radically depending on how one defines it. So we prefer to use the term high performance computing and encompass all of these players in the game.

In the future, we think it is going to be almost impossible to define boundaries. There are chips now coming on the market that have a significant fraction of the power of the Cray I processor, and one can expect in the next few years, possibly the next 5 years, as Senator Gore has said, if not desktops, certainly departmental or even room-size systems will have supercomputer power. It becomes very difficult, then, to identify a very small component of that industry and make policy based on that.

My second point is that to date the U.S. industry and U.S. technology is highly competitive. It has a lot of strength to it. Cray is dominant in the supercomputer, high-capacity supercomputer markets. IBM is certainly dominant. And there is simply no international equivalent to the mini-supercomputers that are being developed in the U.S., not to date. The Japanese are certainly capable, as Dr. Kuck has said. For various applications, it's sometimes hard to even distinguish performance. But at the same time, competitive does not mean that they are in some sense taking over the markets. So the U.S. does have a strong position to lead from in this industry, and it does face obstacles.

A third point is that the government has traditionally, all the way back to the origins of the computer, played a major role in stimulating and developing this industry. Even a hundred years ago, the Census Department played a major role in developing the Hollerith and the punch card technology. World War II saw an enormous amount of research and development which eventually turned, in postwar time, into the U.S. computer industry, which has continued to be closely related to the government R&D programs, government use of systems, and government pushing of technology, particularly of leading edge applications. Defense, Atomic Energy Commission, now the Department of Energy, National Labs, the National Bureau of Standards have all played a major role in pushing these technologies. The DARPA, National Science Foundation—funds research and development, manpower development programs both through fellowships, research assistants, and other research support. And finally, through centers and

facilities. Most recently through the National Supercomputer Centers funded by the National Science Foundation, and leading to now the concerns expressed by Senator Gore for building a national research infrastructure to tie the networking, supercomputing, data archiving and so on, together. So there is a long and noble history of Federal Government involvement in this technology. In fact, there could probably be no more successful story of the Federal Government helping to develop and stimulate a major industrial area than in computing.

Finally, I would like to, without discounting the importance of the trade issue and the international markets, point out that the trade issue as such is overshadowed by the much greater stakes our economy and society in this technology. As was pointed out in fact earlier, it's only a billion dollar worldwide market. What makes it so important? And I would submit that, even if the Japanese and the European did not even have a computer industry that was viable or active in the international markets, these hearings would be important and necessary.

Computer technology, more broadly information technology, is critical these days to research, which in turn is critical to economic growth and competitiveness in our society. It is critical to national security. It's critical to governance. It's critical to the provision of social services, development of new medical care and so on. Industry uses it. Use it for product design, control processes, for distribution. Most recently, I understand the financial markets are getting interested in using supercomputers. They are penetrating throughout the economy. Are important tools in increasing the productivity and competitiveness of the U.S. economy, and for that reason alone are an important topic for consideration by this committee. And it is important to consider whether, and if so how, government should continue or evolve its policies to advance the state of the art.

Thank you, Mr. Chairman. And I'd be happy to answer any questions.

[The prepared statement of Dr. Weingarten follows:]

TESTIMONY OF FRED W. WEINGARTEN
OFFICE OF TECHNOLOGY ASSESSMENT
U.S. CONGRESS
BEFORE THE HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
AND THE SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

SUPERCOMPUTER

June 20, 1989

Thank you, Mr. Chairman, for the opportunity to appear before this Committee to discuss supercomputing and the supercomputer industry.

As you know, OTA is currently conducting an assessment of information technology and research, of which this committee is a principal requester. The assessment includes a comprehensive look at the research needs for access to high performance computing, and Federal policies both for providing that access and for developing even more powerful machines.

My name is Fred Weingarten, and I am directing that project. I am a Senior Associate with nearly ten years experience at OTA, most of which was spent as Manager of the Communication and Information Technologies Program. Prior to that, among other responsibilities, I managed an academic computer center, directed National Science Foundation programs that supported computer science research and computer facility development for research and education, and spent a year at Lawrence Livermore Laboratory, working with its impressive collection of supercomputers.

I am here to provide background on the nature of the supercomputer industry and markets. Our study is not finished, buy I will make some general observations on the current and possible future state of the industry. We are not yet prepared to go into detail about findings and options for Congressional action. We will issue a staff paper with more information on some of these topics in a few weeks; and we will issue our final comprehensive report in about a year.

OBSERVATIONS

1. The boundaries of supercomputing are increasingly difficult to define for policy purposes. As a result, Federal policy aimed at stimulating the supercomputer industry needs to be framed very broadly, and may encompass much of the computer industry.

The term, "supercomputer," despite its frequent use in the press, government, or even by computer experts, is ambiguous. One common definition is "the fastest machine available at any time," but that definition has not proved to be useful for policy purposes. In the first place, "speed" in a supercomputer is an inexact measure that depends on many factors; so "fastest" is nearly impossible to determine. Furthermore, since better systems are continually introduced, a "supercomputer" can become less than "super" even before it has been installed. Finally, the definition omits other types of computers that are closely related to supercomputers and that are of nearly equal importance. In fact, the boundaries between supercomputers and other

types and classes of computers are nearly indistinguishable as the microelectronic processor chips become more powerful and as designers use them to create systems tailored to specialized markets. Not long ago, only one or two computers in the world held the title of "supercomputer," and everyone agreed with the definition. Below those were an assortment of less powerful "general processor" machines, used by but not tailored to the needs of scientific users. Now, the picture is far more complex. Therefore, for purposes of our study and for this testimony, we consider "high performance computers," (our preferred term) to encompass three categories: (1) "Pure" or "Large-scale" Supercomputers; (2) Vector Processors; and (3) Minisupercomputers.

Newly announced processor chips are nearly as powerful as an early model Cray 1 supercomputer of the late 70s. Based on these chips and their likely successors, many experts foresee within the next few years an inexpensive "Cray 1 on a desk." Hence, in the near future, high performance computing technology will span the range from chip to enhancement boards for Personal Computers, to engineering workstations, to minicomputers, to large-scale mainframes.

Furthermore, the technology has become more specialized, as computer engineers create machines specifically designed for particular tasks. A system may be specifically designed for graphics, for example, or artificial intelligence. The technology has grown powerful and flexible enough to allow

such specialization, and markets have developed for these applications. Hence, exceptionally fast machines exist that might be considered "high performance," but are only useful for specific applications.

2. High performance computing technology will see major changes in the next decade.

Looking back ten years, technological change in large-scale supercomputers has been evolutionary. Although components are much faster, they are still silicon-based. Current designs are recognizable outgrowths of earlier machines, and in some cases still run programs that were written for those earlier computers. Looking ahead to the next decade, it seems possible -- perhaps likely -- that the large-scale systems on the market will be quite different. They may be based on entirely new component technologies and incorporate some of the more radical architectural ideas that are being explored in computer science laboratories and brought to market by some small start-up firms.

This scenario, if correct, together with the proliferation of powerful new technologies means that established computer firms in this field are facing great uncertainties and dramatic changes in the market. With Japanese computer manufacturers in the high performance computing market already and Europeans on the threshold of entering the market, it is not surprising that many are concerned about the future of the U.S. supercomputer industry.

Helping the U.S. high performance computer industry deal with this technological transition brings the Federal Government's important role of encouraging innovation in the computer field into historical focus.

3. Federal polices have always been a strong stimulant to the computer industry.

The Government has helped stimulate and support the development of a strong U.S. computer industry in many ways:

- Through research and development funding aimed both at support of basic research and at developing computer technology needed for its own purposes, Government sowed the seeds for the entire industry. Examples date back nearly 100 years to the development of punched-card counting systems for the Census Bureau, and the development of the stored program computer in World War II. The importance of government R&D continues today.

- As a major purchaser and user of computer systems, Government has both created a market and helped develop new applications. This role is nowhere more evident than in supercomputers. For many years, Government was the principal market for supercomputers and worked closely with the vendors to develop technology that would be best for its scientific computing needs. Although computer markets have broadened considerably

over the years Government is still an important influence in supercomputing as it now funds or operates over 60 systems not counting classified systems.

- Government research programs have helped to produce the scientific and engineering expertise needed to develop new computers and new ways to use them. In particular university-based research programs in high-performance computer architecture have produced many key people in the field.

- Government has established high performance computing research centers and facilities. For example, the National Supercomputer Centers established by NSF are becoming important sites for developing new applications, training new users, and experimenting with new designs.

4. Software is a critical determinant for success in the supercomputer market.

A computer, sitting by itself, is of no use to anyone. It becomes useful (and, hence, marketable) only when equipped with programs that make it perform particular tasks. Development of software for supercomputers (or high performance) can be as complex and demanding as designing the computer in the first place. Some important considerations flow from this observation:

- The existence of an extensive software base can be a powerful influence favoring existing market leaders such as Cray or IBM. (On the other hand, it can discourage them from adopting quickly any radically new architectures.)

- Firms trying to market machines based on new concepts must either invest large sums in software development or find "friendly" users who are oriented toward exploring new techniques and developing their own applications. Many scientific users are "friendly" and, thus, research applications of information technology have often led the way into broader markets.

- A major Federal R&D effort on software, including computational mathematics and software engineering is critical to the development of high performance computing.

INDUSTRIES AND MARKETS

Data on the high performance computer industry are incomplete and occasionally contradictory. Definitional problems, as I mentioned above, account for some of this, as does the extremely rapid turnover in some parts of the industry. In addition, data collection of this sort is always difficult, for firms are loathe to reveal proprietary information on their markets. Thus, the data we provide here are rough. Nevertheless, they should be sufficient to provide some impression about how the market stands.

1. "Pure" or "Large-scale" Supercomputers

This class of computer is comprised of very large, powerful machines, principally designed for huge numerical applications such as those encountered in science. These machines are the ones most often referred to as "supercomputers." Several computers are generally accepted by experts to fall into this class. Machines produced by Cray Research, for example, including the Cray 1 (now obsolete), the Cray 2, X-MP, Y-MP, and Cray 3 (not yet in production). The class also includes the Control Data 205 (also obsolete) and the ETA-10, recently pulled off the market. It also includes the top of the line machines made by three Japanese manufacturers, NEC, Fujistu, and Hitachi.

Large scale supercomputers have increased in speed roughly one hundred times every ten years; although speed is a difficult measurement for these computers. There is no reason to think that these high- end machines will not continue that rate of improvement in power. Component technology has not approached its limits of speed and size, so memory and the performance of logic devices should continue to improve at their current rate, and computer engineers will continue to wring improved performance out of design enhancements. At some point major changes in architecture will likely be made. However, because users have large investments in software, compatibility will be a major design consideration.

The world market for large scale supercomputers is now roughly one billion dollars per year. Cray Research (which has now been divided into two companies, Cray Research and Cray Computer) has a majority of that market -- estimates range from between 55 and 65%. With the demise of ETA, Cray Research is currently the only U.S. firm marketing a "pure" supercomputer, but that may be only a temporary edge. The spinoff, Cray Computer Corporation, comes from that part of the original firm that has been developing the Cray 3, and it is expected to bring that machine on the market sometime in the next year or two. IBM has also established a joint venture with Supercomputer Systems, Inc. and may have a product in the early 1990's. Rumors exist about other U.S. firms entering the market, but they cannot be confirmed. Eventually, one must ask how many companies will want to compete for a total world market of 1 billion dollars, even if it is growing rapidly. The cost of entry, to design and produce a new supercomputer, has been estimated to be a minimum of $100 million dollars.

The three Japanese firms -- NEC, Fujitsu, and Hitachi -- have been more successful marketing supercomputers in Japan and Europe than in the U.S., although some observers expect them to start a major effort in the U.S. in the next year or two. Much debate circles around whether the Japanese machines are in fact more powerful than the U.S. systems [despite the high processing speeds advertized], and whether they would be competitive with U.S. systems.

2. Add-on Vector Processors

The IBM 3090, while a very powerful machine, is not considered to be supercomputer class by itself. However, when a set of vector processors[1] is hooked onto the 3090, the system can provide supercomputer level performance for many types of scientific problems. This type of system is the basis of the Cornell Supercomputer Center funded by NSF. Some state and university supercomputer centers operate IBM 3090 vector machines, although none is as large as the Cornell system.

Add-on vector processors are used to increase the computation power of computers of all sizes, from desk-top to large main-frames. Their limitation is that they do not change the general architectural structure of the computer, they merely increase the speed with which computations can be performed once they are sent to the processing unit. Hence, they are limited in the degree to which they can speed the flow of work through a system.

In addition to the NSF funded supercomputer center at Cornell University, perhaps a dozen or more state and university-based centers have IBM 3090 vector processors. The total market for vector processor mainframes has been estimated at about $100 million per year.

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1 A "Vector Processor" is a device, designed to be attached to a mainframe computer, that can perform certain types of arithmentic computation at very high speed.

3. Minisupercomputers

Several smaller, specialized systems have appeared on the market. Some of these machines are based on the structure of a full supercomputer, but they use cheaper, slower electronic components. Thus, these systems make some sacrifice in speed, but cost much less to manufacture. For an application that is demanding, but does not necessarily require the resources of a full-size supercomputer, computation can be much more cost effective on such a "mini." For example, some scientific users develop and test their programs on local minisupercomputers before moving their applications to the more expensive large scale supercomputers.

Another group of minisupercomputers gain computation speed by means of fundamentally different architectures. They are known by colorful names such as "Hypercubes," "Connection Machines," "Dataflow Processors," "Butterfly Machines," "Neural Nets," or "Fuzzy Computers." Although their designs differ greatly in detail, most are based on large scale parallelism, that is, an attempt to get large increases in processing speed by hooking together in some way a very large number -- as many as 64,000 in the Connection Machine -- of simpler, slower and, hence, cheaper processors. The problem is that computational mathematicians have not yet developed a good theoretical or experiential framework for understanding in general how to arrange applications to take advantage of these massively parallel systems or other new architectures. Hence, they are still, in some sense, experimental, even though several are now on the market and being sold. Many experts, however,

think that eventually significantly large increases in computational power will necessarily come from approaches such as these systems or from some other form of massively parallel architecture.

Both current market estimates and projections are particularly unreliable for such new industries sectors. Data are often not available or not accurate for these small, privately held firms; there is great turn-over in the industry with new companies being formed and old ones closing down daily; and no one can agree what is and what is not a minisupercomputer. One of OTA consultants has estimated that as many as 300 U.S. companies report themselves to be designing or marketing minisupercomputers, that possibly a third of those would be generally accepted to fit the category, and that a much smaller fraction are actually marketing or close to marketing a machine.

For what they are worth, some market estimates suggest that the total annual market today is a little over $200 million. Convex and Alliant are dominant in that market at this time, selling vector systems architecturally similar to large scale supercomputer systems. Japanese firms are not active in this market at the present time, although, as might be expected, they are reported to have parallel processing research projects under way. Many analysts expect the minisupercomputer market to be the fastest growing segment of the supercomputer market.

Because of the potential importance of this area of supercomputing to research, the OTA will be looking more closely at it in the next several months.

CONCLUSIONS

Mr. Chairman, we remain in an exciting period of change in the computer field -- changes in the technology, itself, in the way it is used, and in the industry that provides it. It is important that we try to understand and influence how that change affects U.S. competitiveness and economic growth. Furthermore, the importance of these issues reach out beyond the supercomputer industry, itself, and even beyond the computer and information industry; for these technologies have become basic tools for economic growth and social development throughout our society. I hope that our project will make some contribution to advancing that understanding.

If the Subcommittee has any questions, I would be pleased to try to answer them.

Mr. WALGREN. Thank you, Dr. Weingarten. We appreciate that.

Let me just ask your assessment of the role of discounting machines in this—of this type, in their being sold to Europe and inside Japan and how the smaller segment of the supercomputer industry that you talk about in its broader definition—aren't these smaller firms at a great disadvantage in competing in an area where discount delivery is very—where that makes a great deal of difference as to what happens?

Dr. WEINGARTEN. Well, Mr. Chairman, we haven't looked specifically at issues of dumping or discounting of computer systems. Certainly, as has been pointed out in the press, there is a long history of U.S. firms discounting systems for educational purposes. In fact, now one of the major discount programs is run by Apple Computer, which significantly discounts its systems for educational use. But at the same time, these firms are very large, particularly IBM, Digital, and so on, that historically have done such a thing.

The supercomputer manufacturers, the makers of the minisupers and so on are not large. When they develop a new system, they essentially bet the firm on the R&D for the next generation model. They only make maybe 50 or 60 a year, so they really can't afford to go and give them away. Now, to the extent that that provides a disadvantage, a marketing disadvantage between firms, I suppose that can be the case. I don't have a particular comment on the international trade implications of that. We have not studied that.

Mr. WALGREN. I see. Dr. Kuck, do you have any comments you would like to make in that area of discounting and the relative size of American peripheral firms?

Dr. KUCK. I am not an expert in that area.

Mr. WALGREN. Okay.

Dr. KUCK. I'll decline.

Mr. WALGREN. Well, let me recognize the gentleman from New York, Mr. Boehlert.

Mr. BOEHLERT. Dr. Kuck, what impact do you think that our Supercomputer Centers program is having on the teaching of computational sciences?

Dr. KUCK. Not as much as it should have had, in my opinion. I think that most of the teaching in American universities of computing goes on in computer science or electrical and computer engineering departments. Those departments have not risen to the challenge. Most of the use is on the science side, in chemistry and physics departments, and in some engineering departments, biology departments. And so what's really happened is that people are drawn away from their discipline oriented work. Physicists start learning how these computers work and folklore grows up and software gets written. And people are probably doing more sharing now of software than they were before. But, as far as non-research-level teaching, that's what I was complaining about a little while ago. It hasn't happened.

Mr. BOEHLERT. You know, I've only been on this committee 7 years and I can recall my first year, right at that table where you're sitting, Ken Wilson, who at that time was at Cornell, a Nobel Laureate and a national asset. He since switched to Ohio and we miss him in New York. But I can remember him telling us,

and I was just astounded by it, that the average graduate student in Japan or West Germany or Great Britain had access to the then version of supercomputer technology, ready access, and he didn't. It seems to me that we've come an awful long way in a short period of time. I'm not satisfied with the progress we've made. I'm anxious to accelerate the pace, and I think the administration is too. As Senator Gore and I were having a little colloquy there, the problem is not so much with the administration or with this committee, it's with our appropriators.

But we now have—what?—5 Supercomputer Research Centers, of which yours is one. How about the adequacy of the funding? Do you think the Federal Government, through the National Science Foundation, is meeting its commitment to these Centers?

Dr. KUCK. I should say I'm not part of the Illinois NSF Center. We have two Supercomputing Centers in Illinois. Mine is doing research and development of such systems.

Mr. BOEHLERT. Okay.

Dr. KUCK. I think they're being reasonably well taken care of. I think now they have a new funding period. They, I believe, have had to scramble too much to get industrial support on the average, but they seem to be prospering on the whole.

Mr. BOEHLERT. What is your discipline, Dr. Kuck?

Dr. KUCK. Electrical engineering.

Mr. BOEHLERT. I wonder, one of the frustrations we experience here is that we sit here day after day and hear a lot of wonderful things about a lot of wonderful opportunities, and we don't do a very good job of prioritizing, and neither does the administration. I don't think anyone yet has come up with a magic formula allowing us in some sensible way to assign points and come up with a pretty good list of priorities.

Off-the-wall question. Forgive me, with that introduction. But should we be going ahead with some expensive new ventures like the Superconducting Supercollider at a time when we don't seem to have enough money to go ahead with adequate funding of the Supercomputer Research Centers and the program that Senator Gore is referring to, which I am enamored with and would like to proceed with?

If you were prioritizing, give us some advice on how to do that, would you, please?

Dr. KUCK. Of course my own field gets a high priority, but I'd like to just come at the thing that I was trying to say earlier from one more angle. And that is, that the NSF Centers have not done a whole lot to advance the architecture, the system software or perhaps even broadly used applications software on those machines. Computer companies usually have short fuses and don't have the time to do everything they ought to be doing. The usability of those machines, the instability of the performance of them is all related, in my opinion, to not enough thought, and, i.e., not enough money probably, to understand these problems sufficiently well, so that we could have machines that were broadly useful.

I think the amount of money—I think that in the new Gore bill there is some attention paid to this question. I think it ought to have a high priority relative to some of the other items that are in there. And I think it is important to realize that computers, and

supercomputers which have a trickle down effect on all other computers, are basic; and so compared to Superconducting Supercolliders or a particular big ticket NASA item, these are relatively small cost affairs, I believe.

Mr. BOEHLERT. One final question. To what extent do you think the American supercomputer industry is hamstrung by the small size of its companies?

Dr. KUCK. Again, they produce on a very innovative set of machines on a very short time frame. What's needed—the usability of those systems, more time or a wider research-oriented setting in which these machines can be developed and software can be developed for them.

Mr. BOEHLERT. Dr. Weingarten, do you have any comment on that?

Dr. WEINGARTEN. Yes. I think the real problem they have is when it comes to finding markets and developing the applications of the hardware itself. Computers are different from other kinds of products on the marketplace in that, in order to make them useful for something or for somebody, the application software—you have to learn how to use them. And so a very innovative new computer architecture requires an environment in which this layer of software, this layer of knowledge on how to use it, has to be added to make it marketable. And it's been—in the past it's been the Federal Government as a user, as an early user of some of these technologies, that has provided that incubator which the smaller firms are often too small to provide.

Other than that, in fact, I think they do have some great advantage because they are much more flexible. They can be far more innovative and move much more quickly. I think some of the very large computer companies just are bewildered by how fast new ideas in computer architecture come out on the market and compete with one another. It's a very fertile and exciting field to watch.

Mr. BOEHLERT. Do you see any change in the structure of the industry?

Dr. WEINGARTEN. Well, certainly over the many years I've been involved with it. It used to be IBM and seven large mainframe producers, and now it's a much more diffuse industry with lots and lots of startups. There are firms that have started in just recent years making small niche machines that are now major producers. Apple Computer comes to mind. I was in this industry when Digital first started making minicomputers, which were considered to be niche machines, and now Digital is the second largest manufacturer in the country. So it is certainly a very fertile, fast moving field.

That's all.

Mr. BOEHLERT. All right. Thank you very much. Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Boehlert. Mr. Price?

Mr. PRICE. Dr. Weingarten, I'd like to continue this line of questioning about the structure of the industry. You stressed in your testimony the number of small firms that are in the business in one way or another. Yet, as you know, there've been a number of predictions that have it that we may be looking eventually at an

industry dominated by some very large companies, by a few very large companies. The U.S. companies that manufacture supercomputers, as I understand it, are all small, relative to their Japanese competitors, for example, NEC, Fujitsu, and Hitachi. Japanese companies, it's said, have a large advantage in pricing their supercomputers since they can afford to offer large discounts in order to penetrate markets. And some have predicted, because of that pricing and marketing advantage, that we may eventually be looking at a supercomputer market dominated by, some have said, even the three large Japanese companies and IBM. What do you make of that kind of prediction? Are these small U.S. companies in the end going to be able to survive?

Dr. WEINGARTEN. Well, I would hate to try and predict. I think that's one scenario that's—

Mr. PRICE. The earlier question, you know, had to do with the future structure of this industry, and you've stressed the ability of these small companies to find a niche, to innovate. I'm asking, I suppose, whether the marketing considerations may move in the opposite direction?

Dr. WEINGARTEN. The U.S. firms do have advantages. There is a large embedded software base. There is a very large, in some sense loyal consumer base. And, unless the Japanese machines become clearly superior to machines offered by U.S. industry, so clearly superior that users are willing to overcome the enormous transition barriers, I would say that the U.S. firms have some advantages that they can use.

On the other hand, I'm not trying to discount the concerns over Japanese competition. That does not mean that we should be sanguine, that we should back off, stop funding computer research, stop funding centers like Dr. Kuck's, stop building National Supercomputer Centers or funding next generation machines. It doesn't mean that at all. In fact, it's in our national interest to push these industries and this technology as fast as possible.

But the scenarios that are drawn that somehow picture an inevitability of the Japanese industry, simply because of its size, to overwhelm the U.S. firms is a scenario, but it is not necessarily the only one that people would draw.

Mr. PRICE. Dr. Kuck, if I could turn to you for just a moment, I, and I suspect other subcommittee members, found your testimony disconcerting, your suggestion that we aren't really doing the kind of research and development we need to be doing, that a number of architectural and software problems remain to be solved, and that intra-industry efforts really aren't doing that job, nor are university research efforts. You didn't make much in the way of an explicit international comparison. I'd like to ask you to do that. Are these kinds of research and development efforts being made in other countries?

Dr. KUCK. Well, it's hard to generalize. I think in Japan, in fact, universities—professors in Japan do their research work in a company, so there isn't the same model exactly, but there is inter-industrial activities of all kinds in Japan that are much more aggressive and much more able to pull things off than American companies are. Go ahead.

Mr. PRICE. I'm not so much asking how that effort is structured. I'm rather asking whether the basic work that you've identified is being done by whatever structure.

Dr. KUCK. I think that this country, in terms of innovation architecture and in struggling with the issues of how to use these machines, is the world leader at this moment. I don't see any problem there. I see, though, that if we don't understand how to make parallel processing work, how to use—at this moment, you know, until a few months ago at least, of the couple hundred Cray XMPs installed in the world, only one was being used as a parallel machine—four processors, everybody uses them as four independent things. The European weather forecasting people are the only people who know how to make four of them work together.

My point is that more thinking like that has to happen, more interchange of these ideas, and it has to be worldwide. I don't think that you draw national boundaries there.

Mr. PRICE. You say that the role of the NSF Centers, while it is quite positive, has really not made an appreciable difference in this regard. Is that what you're suggesting?

Dr. KUCK. In the sense of—right, in that regard.

Mr. PRICE. What you would suggest, then, that the thrust of the next Federal effort ought to be? What precisely is the optimal Federal role in dealing with this shortfall in research and development?

Dr. KUCK. I, unfortunately, I don't know the answer to that question exactly. I can give a couple of comments.

Mr. PRICE. We would appreciate that.

Dr. KUCK. I think those Centers are going to mature. I think that we did a—a National Research Council Computer Science and Technology Board that came out with a survey result a few weeks ago, which you might want to take a look at, which surveyed industrial and national lab and university users of supercomputers. And I won't go into the details, but you can see very easily that the new people to the field, and university users in particular, are pretty naive. They are very excited about going from a VAX to a Cray. And they somehow see this as an unlimited future growth of speed, whereas the DOE or the national lab users are very jaded and say, "Hey, these machines aren't nearly fast enough for us."

So, as those university centers mature, I think they'll start to work on—some of the problems that need attention will start to get attention in those centers. On the other hand, they're not really set up to do research and development in supercomputing per se. We have a center at Illinois. There's a center at Caltech. There's a center at NYU. There's some work at M.I.T. But there aren't more than half a dozen places in universities in the country that are doing research in supercomputing and parallel processing in a multi-million dollar a year way. And, as I mentioned, in companies it's usually a short fuse.

And, so I like the SRC style. There are hundreds of professors. Every NSF proposal that comes along is working on parallel processing these days. But they get very theoretical; they get very abstract. It gets very far away from what's needed by those people who are using these machines. So a mixing together of problems and money is what I'm driving at.

Mr. PRICE. So it does, what you're saying does imply some concerted effort on the part of NSF to encourage these research directions to—

Dr. KUCK. I think so.

Mr. PRICE. —to offer incentives in the form of funding and in the ways you've identified?

Dr. KUCK. And perhaps other agencies to be less oriented towards the problems that they have in mind and more oriented industrial-type of questions.

Mr. PRICE. And you have that in mind, that kind of emphasis within the agency in mind, rather than some kind of new program or new structure or different way of setting up the governmental role?

Dr. KUCK. I'm not—I don't know how to address that question very well. But the SRC's model, I like. That's a place where companies join together with some universities. Companies put some money in, and they say: "Now here are our problems. You submit proposals. We'll fund the ones we like." And the people who have this money in universities are still allowed to do pretty much academic-style research, but it's focused on the problems of the semiconductor industry. The difficulty we have here is Cray and many supercomputer companies and so on have a certain class of issues that they'd like to have worked on. The end users have another class of problems that they're trying to have dealt with. And so it's a broader integration. I refer back to Ken Wilson, who constantly tried to get a very broad interaction between users and manufacturers and academic types. He wasn't able to pull it off.

So I don't know what the answer is, but something like that needs more attention.

Mr. PRICE. Thank you. Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Price. Mr. Campbell?

Mr. CAMPBELL. Mr. Chairman, not having had the benefit of hearing the testimony, I don't have any questions. Thank you, sir.

Mr. WALGREN. In this business, none of us feel we've had the benefit of very much, not matter what—

Mr. CAMPBELL. Well, in that case I'll take several hours then.

[Laughter.]

Mr. WALGREN. The SRC Center is university and business focused. Are you drawing Federal funds into that?

Dr. KUCK. I'm not involved with it, and I haven't talked to them lately. But at least initially, they didn't have—I don't think they had any or very little.

Mr. WALGREN. Yes. I guess I'm wondering is where do we look to get the development of the parallelism in software, where do we look to get the research done to do that. In the National Science Foundation Supercomputing Centers, they're not really directly focused on that. Indirectly, it tends to happen I guess, but what you're saying is—is that the software is underdeveloped and some real research application in the software area alone can give great leaps forward in capability.

Dr. KUCK. Right.

Mr. WALGREN. And interesting, you said that only one place in the world are they using the four units as parallel units.

Dr. KUCK. If John Rollwagen is here, he can address that. But six months ago that was still true.

Mr. WALGREN. So the parallelism is really underdeveloped.

Dr. KUCK. Absolutely.

Mr. WALGREN. And the question is how we can bring that along.

Is there not a great potential in this business too to be able to lock people in by the software?

Dr. KUCK. You mean customers?

Mr. WALGREN. Yes.

Dr. KUCK. Well, as I've mentioned, there's this performance portability issue. You tune it all up on this machine, and you try to move it to the next machine, and, hey, start all over, on the average. I mean, for most applications you have to rethink things.

Mr. WALGREN. So, from a national perspective, who—which side or which—even individual producers come up with workable software that covers a range of problem solving that someone wants to use it for. That's where the sale is going to go.

Dr. KUCK. Right.

Mr. WALGREN. Because we probably all at least learn that we don't buy a computer if we don't know how to use it or can't use it.

Dr. KUCK. Right. And what the common man who reads these supercomputer articles in the newspaper doesn't quite see is that the sequential machines—the Macs and the IBM PCs—have entered a trivial to use phase, whereas supercomputers still have some distance to go. Parallel processing, the surface is only being scratched.

Mr. WALGREN. You indicated in your testimony that parallel Japanese systems are expected in 1990. Where are they in this software development?

Dr. KUCK. Well, I should say—I don't know. I should say, though, that in the '70s when they wanted to get into the vector business, they went, all three, straight ahead, read all the American papers, studied all the software in the world, and wrote pretty good compilers, and started on applications software for those machines in a vector sense. And they did it pretty much by themselves. They are now, obviously, looking at multi-processing or parallel processing. NEC has announced a machine. Fujitsu, my Japanese friends say, has one very—a year away or a little more than that. Hitachi I don't know about. My guess is they won't—they'll come with some interesting software when they come with the hardware.

Mr. WALGREN. I see. Well, okay.

Can you make a comment, Dr. Weingarten, on the ability of the software to market the machine and to essentially eliminate competition in the market in this area?

Dr. WEINGARTEN. Well, software has almost always served to embed a user with a particular line of computers. Portability has always been a problem—a problem or an advantage, one way or the other, depending on what direction you're looking at it. But the real software problem, I think, as Dr. Kuck is raising it, is a lack of knowledge or a lack of any software base for using these new architectures, or lack of understanding, a basic understanding of how to do it.

So there are two or three levels of problems. One is a lack of software engineering knowledge and basic knowledge of parallel algorithms, computational mathematics, which needs additional re-

search support. The other is the development of applications programs for users who simply aren't in a position to understand this technology and develop their own software.

Also, I'd like to point out that the—at least as I understand their role in the ecology of computing—the National Supercomputer Centers are really addressing the second need in the area of scientific research. So, in some sense, they are pushing the state of the art, but they are doing so by helping develop applications systems and applications software within scientific research. Much of that software then can be transferred into industry and into other kinds of applications, because there are enough similarities between the kinds of physical modeling, the kinds of optimization programs and so on that scientists run and the uses in industry that they serve as this incubator that I was referring to. But the other need in software is for the basic research, particularly as systems. There are also two degrees, or there're many levels of parallelism. With the very large supercomputers, parallel means 2, 4, 8, as many as 16 processors. In some of the what I call radical architectures, it may mean 64,000 processors. And those are really quite different kinds of problems, quite different kinds of issues that are addressed in making those systems useful.

Mr. WALGREN. Thank you. All right. Well, on behalf of the committee, we want to thank you both for your testimony and being a resource to us. Thank you very much.

Mr. WALGREN. The next panel: John Rollwagen, Chairman and Chief Executive Officer of Cray Research, and Lloyd Thorndyke, Senior Vice President of Control Data Corporation, and the former Chairman of ETA Systems.

We want to thank you both for coming and for your patience. I know that you have members on the committee that are particularly interested, and the next panel has one of Mr. Campbell's constituents. But we appreciate you being here. You both are real—you're the real world in this area, and so we're pleased to hear from you.

So, please, written statements will be made a part of the record, and you can feel free to focus on anything or any part of your testimony to underscore the points you'd like to make for the verbal testimony.

So let's start with Mr. Rollwagen.

STATEMENTS OF JOHN A. ROLLWAGEN, CHAIRMAN AND CHIEF EXECUTIVE OFFICER, CRAY RESEARCH, INC., MINNEAPOLIS, MINNESOTA; AND LLOYD M. THORNDYKE, SENIOR VICE PRESIDENT, CONTROL DATA CORPORATION, [FORMERLY CHAIRMAN, ETA SYSTEMS], MINNEAPOLIS, MINNESOTA

Mr. ROLLWAGEN. All right. Fine. Thank you, Mr. Chairman.

First, I'd like to say that I'm very grateful for the opportunity to be here and—switch this? Is it one? There we go. Okay. Sorry. Start again.

I'm very grateful to be here and have this opportunity to talk about our industry for your committee. And I want to applaud you for your interest in our industry and the impact on the country as

a whole. Obviously, I'm not an objective observer, but I truly believe that it has national significance.

I'd like to highlight just a few things from the written testimony, which you have. Talk specifically about structure at two levels: One with regard to our company because of some recent events that may be of interest and have some significance for the industry as a whole; secondly, the structure of the supercomputer industry overall, as I see it. And, finally, the key points that I think you as members of the U.S. Government should be concerned about and where you can have a major impact, I believe, in our business.

First of all, you may have read recently that our company has undergone a significant restructuring. In fact, we've split the company into two parts: one concentrated in Colorado, developing the Cray III product line; and the other concentrated in Minnesota and Wisconsin, continuing the development of our current YMP product line and a new product called the C-90, along with all the attendant software.

I bring this up, not so much to talk about Cray Research specifically and to put in a commercial for the company, but I think it reflects some important developments that have significance beyond just our company. First of all, the main reason that we split the company in two is that we see an opportunity, in fact, to pursue two very distinct and important lines of technology to produce—to continue to produce the world's most powerful computers. In a sense, we were faced with a Solomon's choice of what to do with these two lines of technology within the same company. Normally, we might have been tempted to choose one or the other and go with it. In looking at the situation, though, we decided to go with both.

That's good news in the sense that we see two distinct technologies to pursue that can be very significant. And secondly, we see the opportunity to apply those technologies, being large enough potentially, indeed, to support both of the technologies, and probably much more actually than just what goes on inside Cray Research. The company therefore is making, we feel, a very large commitment to proceed as aggressively as we can to continue our leadership role, in effect, doubling our bet, doubling up our activity and giving it the form of this new structure with two companies.

There is a second reason which leads into the second structural point I'd like to make about the structure of the industry. It is that we believe that the supercomputer industry is becoming, is just becoming, in fact, an industry. When our company was organized, in the early '70s, we could identify precisely 86 potential customers for these large-scale systems in the whole world. That, obviously, isn't a very large number, and it isn't worth having a subcommittee hearing of the Congress of the United States to worry about, frankly.

But something has happened in the meantime, since those early '70s, such that we're not looking at this small niche marketplace confined to a few primarily government-supported research laboratories around the world. We're looking at a much, much larger kind of situation. Just in our own experience, we now have something like 170 customers, of those original 86. And we're probably talking to another 400 or 500 companies and organizations that

could be users of our equipment. So there's at least an order of magnitude difference in the market opportunity as it is today.

At the same time, today I believe that we're as much on the threshold of this business as we were in 1975. And that may sound strange, given the kinds of development we've had; but, potentially, I believe that supercomputers, being defined as the largest kinds of computers around with some range—I don't know what it is, but, you know, big computers—will be used every day by every single scientist and engineer in the developed world in the 1990s. That this is a very significant development. As it was described to me by Paul Grey, who is the President of M.I.T., he said, "John, you may not understand precisely what's happening here." He said, "For 300 years we've relied on two basic methods to develop scientific knowledge. One is mathematical theory as started by Descartes in the 1600s, and the other is empirical observation as typified by Newton and his apple in the same time period." In his mind, and in others as I have heard it described, the development of numerical simulation has the same significance as a method of exploring science and technology in the future. If that's true, and I believe it is, I will stand by the statement that every single scientist and engineer some time in the 1990s will use a supercomputer as an ordinary part of his or her work. We are not even close to that kind of a situation, and there are many things that have to happen to bring that about—technical things, commercial things, but that's the potential we're talking about.

As a result, we think that the supercomputing industry is in fact becoming an industry rather than a niche market. And this may sound strange in a way, but we really believe that for an industry to be an industry there has to be more than one supplier. And, if we're going to have a U.S. industry, there needs to be more than one U.S. supplier of supercomputers. At the current moment, based on our definition at least of supercomputers, we are the only supplier, except we're taking action now to create another one and to have two.

That leads me to the general structural point I'd like to make about U.S. supercomputer industry and U.S. high tech industry especially, but U.S. industry in general. And that's the—we have a system, I believe, that, when we work it, works very well; based on innovation; based on competition; based on smaller kinds of companies being able to innovate and move forward very rapidly and very aggressively. We understand that that's where we, Cray Research, came from. We're still small compared to our largest competitors, especially in Japan; but, on the other hand, we're much larger than we were when we started. And we see advantages in dividing in this case, and in a strange sort of way in this case, the parts being larger than the sum of the whole, if that makes sense.

So that we see this mechanism still being in place in the United States; still working. And we have great confidence that both Cray Research and now Cray Computer Corporation can in their respective forms be successful and both play a leadership role in developing supercomputer technology along with others as they enter the field. We also don't imagine, if the opportunity is as large as I think it is, that our two companies now will be the only companies in this business, even in the kinds of computers that we make.

As a result of the structure of the U.S. supercomputer industry right now, it is fair to say that we have leadership in most areas. We have the leadership in infrastructure, in terms of sales and support services, in terms of software, in terms of hardware. Across the board we do, in fact, lead this industry in the U.S. We lead it from a worldwide standpoint, and I don't think anybody would really argue with that. We recognize at the same time that, as the industry and the market has developed, we have serious competition coming. But I want to emphasize the point that today we have a leadership role.

If you ask me to quantify that, it's difficult; but, I would say in the range, from at least a technical standpoint, of about 2 years, which is not a long time. But at least it's a leadership role.

We lead specifically also in parallelism, in multi-processing, both at the level that has been done at large-scale systems—as one of the earlier witnesses was testifying, 2, 4, 6, 8 kinds of levels—but also I believe, although we're not active in the field ourselves, also in massively parallel machines. And I know you're going to be hearing from Sheryl Handler later in the meeting, and I'm sure she can be more specific about that—or someone from Thinking Machines in any case.

We have the largest set of customers in the world. And I want to emphasize the customers not just from the standpoint of where the money is, people who buy these machines, but I would argue that our—at Cray Research our largest single technical asset, beyond Seymour Cray or any of our engineers or any of the facilities that we have within our company, our largest single technical asset is our customer base. Because now we have 170. If an organization is telling us in no uncertain terms how crummy our computers are and how much we have to improve, and showing us exactly where we ought to do that—now, they don't tell us how to do it exactly, but at least they point the way. Furthermore, they show us a lot about what they're doing with the machines, what kind of challenges they're running into. And through that route we know a lot, in fact, I suspect more than anybody else, about what's happening—at least institutionally about what's happening with the application of supercomputer and where the soft spots are, which it guides us therefore in our research and development. And I'm going to come back to that point.

We clearly lead in the application of supercomputers from a technical standpoint in terms of programs that have been developed to do specific functions. In our case, we have well over 500 major applications that run on our systems, and no one else has that position.

There is one area, however, that I am very concerned about and where our leadership, if it exists, is clearly eroding. And I think it has been referred to earlier. And that's in the use of these supercomputers for real live problems, particularly in the commercial sector. What we're seeing at the present time is a much more aggressive approach to using these machines in the development of other science and technology and other products in Japan than we see here in the United States. We see the Japanese companies in particular being much more aggressive in acquiring this technology and using it in their own laboratories to develop competitive prod-

ucts. And this is the area where the future is, I believe, in the application of these machines.

When I said that every scientist and engineer in the world will use—in the developed world at least—will use this equipment, most engineers and scientists are in the commercial sector. And most of them, at least if you define that broadly—in Europe, for example, where commercial concerns are owned by the government, so it is kind of gray, but at least in—participants in the commercial sector—and most of them work for smaller organizations than the kind that can immediately or easily afford a $10 or $20 million computer. And this is a challenge for us, for us at Cray Research and I think for the country as a whole, to deal with this phenomenon as we go forward.

Now let me just talk briefly about the areas where I think the United States Government has a key role—has already played a key role and will continue to play a key role. First and foremost, and I assume you'll hear this from others, you buy our products, and that is essential. It probably in our case represents—it's hard to measure directly because sometimes contractors for the United States Government buy the product; and, if I include them, probably 40 percent of our business presently, in dollars and cents, comes from United States Government sources—very significant for us.

At the beginning of Cray Research, a hundred percent came. I mean, our first machines went to Los Alamos and Livermore and ANCAR in the Defense Department, and various applications. I cannot underestimate the significance of this factor in creating the industry in the first place and continuing to provide support to the industry in what I believe, or we believe at Cray, is the most efficient manner possible. What I want to say here is that the job isn't over, that we are in a continuous development effort, we are in a continuous competitive struggle, and we need your continuous support in the same way.

What makes me feel good about this is that I'm not coming, or Cray Research is not coming, hat in hand, saying that we need a contribution, a charitable contribution of some kind. We believe that the products that we and our fellow members of the industry provide have great value, and therefore we both win. The U.S. Government wins, and we win in terms of continuing this business. And I would encourage you to, where appropriate, support the procurements that are allowing this to happen.

Secondly, though, I think that in purchasing supercomputer equipment it's important to recognize that this is not a commodity purchase. Right now we fall under the guidelines of—I don't know the formal terms, I should—but of the ADP procurement rules within the United States Government, which are not inappropriate but apply to more to a commodity-like purchase—where it is going to be done on a competitive bid basis and you're buying essentially the same product, or could buy the same product from multiple vendors, and therefore you want to get the best price for that product. That doesn't really work in our business in that, particularly at Cray Research, we often find ourselves, for instance, offering the most expensive computers in the world. And by definition, if you take a simplistic view, we will never win a competitive procure-

ment because we are the most expensive. If the simplistic route is to lower the threshold of performance so as to qualify another vendor, as soon as that happens and you just take it dollar for dollar, we're going to lose. Now, obviously, that's not a sensible way to acquire this kind of technology, but it does present some challenges within this procurement process. Your understanding of that, and allowing for sole source procurements, allowing for evaluation of performance of the system, and giving dollar credit for that is important—that kind of thing. And that, obviously, doesn't apply just to us, but to all of our—all of industry members.

Another very important factor has to do with international business. This is clearly, much more than it used to be, an international affair. We are competing worldwide—for business worldwide, and we are competing worldwide with other suppliers outside the United States, most notably the Japanese, of course. The government has a very important role, we feel, to play in working with us in this competitive struggle. In one case, and I acknowledge that we're getting some significant assistance in this right now, we are faced with an anomaly in Japan where we do not have access to the public sector marketplace in Japan. This has been recognized now. The reasons for it have been documented; and, as you all know, this case has been cited in the application of the super 301 provision of last year's trade bill.

But this is a real case. It's true, and it's ironic because in every market where we've done business we've started in the public sector and then branched into the commercial sector. We're having some success in Japan in the commercial sector, and we're having zero success in the public sector. And I'm hopeful that the actions that we're taking will allow us to do that business.

Secondly, and this is a knotty issue, one that's difficult to deal with in international affairs—it has to do with export licensing. There are clear security issues having to do with the use and access to—use of and access to supercomputers for intelligence purposes or weapons design, strategic purposes from a military or a national security standpoint. And this is clearly understood, and we have to exercise great caution. At the same time we feel that there is a great security advantage in providing leadership in the supercomputer field, and the way the world works these days is that, and not just in supercomputers but in many fields, our advantage does not come from having access to specific natural resources or physical items. It's really based on knowledge and the application of that knowledge.

To illustrate that, in terms of our computer, when we sell it, the cost of the materials that we buy to go into it probably represents 10 percent of the price of the machine. The other 90 percent, therefore, comes from the knowledge that's built into that machine and the design and so forth. And in dealing with knowledge as the base for value, several things have to be observed: That knowledge is perishable; it goes away with time; knowledge value depends on the recipient of the knowledge as much as it does on the intrinsic value of the knowledge; and that knowledge begets knowledge; and that the best way to maintain our leadership in coming up with new knowledge and new understanding is, in fact, to exchange our current technology for other technology.

I hate to go through this long thing but it's important, I think, to understand it. Let me illustrate it one simple way. If I have knowledge and I sell it to you for money, that's interesting because knowledge is not an exchange transaction. If I sell you the knowledge and I take your money, you have my knowledge. I have your money, but I still have my knowledge. Okay? Well, that sounds like a good deal for me. But, in fact, that's a crummy deal for me because in addition to my knowledge you have your knowledge and I don't have it, and the combination is worth a heck of a lot more than any money you gave me for my knowledge.

The point I'm trying to illustrate is that, if we're going to move forward, the best transaction is I'll trade you my knowledge for your knowledge, which means we both have each other's knowledge and therefore can start moving forward in a way that we couldn't before with our own knowledge. But by doing that, we just leveled the playing field once again. We just shuffled the deck again, and we had to start out there this constant requirement to invent, to be innovative, to move forward. And the best way to do that is to exchange knowledge.

So how does that apply to supercomputers? If I use—I want you to think of a supercomputer as not only knowledge in itself which can be exported and can create knowledge overseas, but it is also a source of knowledge back the other direction, back our way. By participating in that international work, we are enhancing our own knowledge. We're learning about what's happening. I'll use a simple example. In the automobile industry right now we have, I think, 16 systems installed, 3 of which are in the United States and 13 therefore of which are overseas, half of those are in Japan. If we for some reason in the interest of national security were to confine our use of computers only to the U.S. industry, we would not be doing business with those 13 installations overseas. That would be expensive from a financial standpoint, but it would be much expensive from technological standpoint. Because we wouldn't have the insight as to how the machines are being used at those different sites around the world which allows us to improve our own supercomputers for their purposes, which then spills over into other applications.

So the only deal I'm doing is making a case to say that there are clear security concerns that must be protected. There are also clear incentives to have us participate worldwide in this business so that we can maintain our leadership.

Finally, from a government initiative standpoint, for supercomputers to be used as broadly as I've described with every single scientist and engineer, two—in my opinion—two main things have to happen, which I think can get—can use and deserve support from the United States Government.

One is in the development of software, particularly applications software to use the machines effectively. The NSF program—Mr. Boehlert, you were talking about that earlier—the NSF program has had major impact, in my opinion, in that regard, and it has been very positive. It's not enough, but it is very, very positive and is moving forward. More of that needs to be done, and through the NSF as well. But maybe there are other places.

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And second, access to the computers need to be provided, physical access on a national scale, which calls for a network. And what has been proposed in at least one case is the 3-gigabit fiber optic network that would interlace the country with superhighways for access to these computers. I believe those kinds of infrastructural issues need to be dealt, and we need to move aggressively on them.

I'll stop with that.

[The prepared statement of Mr. Rollwagen follows:]

STATEMENT OF JOHN A. ROLLWAGEN
CHAIRMAN AND CHIEF EXECUTIVE OFFICER
CRAY RESEARCH, INC.

ON THE

U.S. SUPERCOMPUTER INDUSTRY

BEFORE THE

HOUSE SUBCOMMITTEE ON
SCIENCE, RESEARCH, AND TECHNOLOGY

OF THE

HOUSE, SCIENCE, SPACE AND TECHNOLOGY COMMITTEE

JUNE 20, 1989

Good afternoon. I appreciate being asked to testify on the health of the U.S. supercomputer industry as well as the opportunity to offer some special comments on Cray Research. Clearly, our industry has been rocked by a number of recent events, the strategic impact of which will only become known at some future point in time. The events to which I refer are the exiting of Control Data Corporation from the supercomputer business; NEC's claims for future product purportedly competitive with leading-edge products of Cray Research; and the restructuring of Cray Research into two separate companies. In the interest of time, I plan to discuss the following: 1) The Cray Research restructuring, because it is important to our industry as well as to its long-term effects that this event be understood. 2) I will also highlight very briefly some areas of structural difference between the industries in Japan and the U.S. I won't go into this in much detail at this time, as many of these issues have been mentioned in the press for other industries and I can submit a more complete discussion if you so desire at a later date. 3) Because of the importance of a national focus on the U.S. supercomputer industry and because there are a number of currently disjointed initiatives active within the United States Government (USG) that can affect the industry and Cray Research, I will discuss some of Cray Research's current thoughts on the possible role that USG can play that we would see as positive for the industry.

Restructuring of Cray Research

On May 16, 1989, we announced the restructuring of Cray Research. We have created a second, viable, supercomputer company under Seymour Cray with a solid technology base: Cray Computer Company (CCC). We have created a downstream competitor for ourselves and for the industry. I believe the technology base of the U.S. supercomputer industry has been strengthened by this move.

Traditionally, as you are all aware, companies fund R&D to ensure their continued long-term market viability. In companies such as ours, where our mission is the development of leading-edge products, the risks and uncertainties associated with completing projects on time and for a well-defined investment threshold of amounts of investments are commensurately much greater. By providing CCC with a strong technology base of both hardware and software and by providing sufficient cash funds to complete the product development, the momentum already set in motion by Seymour Cray and his group is preserved and the U.S. supercomputing technology base will benefit. This leads me to my next point: structural issues within the supercomputer industry need to be addressed for the long term viability of the U.S. supercomputer industry.

Comments on Structural Aspects of the U.S. Industry

The U.S. has many computer architectural options to achieve supercomputer performance goals; some of these have been embodied in products and offered by viable, commercial companies such as that of Thinking Machines, whose president is testifying here today. There appears to be a consensus that U.S.-based supercomputing is necessary for economic as well as national security. The focus of national bodies, such as this one, on the U.S. supercomputer industry will help to reinforce this crucial fact and strengthen an essential consensus. Our major competitor is the nation of Japan. The national policy of that country has been clearly stated - their intention is to capture the world-wide supercomputer industry for themselves.

The U.S. has been the market leader and technology leader of the supercomputer industry. It is well-established that being the technology leader is not always the most profitable industry position. It is not always the easiest role in a rapidly growing

and changing marketplace. The supercomputing industry is just beginning to mature. The uses and users are still changing; new applications of supercomputers will be able to change the course of industries critical to the national security or even industries that have become staid but where the application of technology can provide an additional and perhaps a unique edge.

The groups that follow the technology leader can judiciously choose where to allocate their resources. They can innovate in different ways. They are able to learn from the mistakes that the first implementation reveals; they are able to look at an already existing idea, analyze it for where application of additional engineering resources can make a cost difference or where additional R&D can provide a better solution or where additional R&D can address a whole new set of market applications. Japan has had this option.

U.S. industry is full of innovators. Many U.S. companies, for example within the electronics industry, are innovating or have innovated entire industries. Many of these companies are small or medium-sized. They are not monolithic, vertically integrated companies like those in Japan. Just by way of reference, Hitachi's revenue for 1988 was $23.9 billion, NEC's was $18.9 billion and Fijitsu's was $15 billion, based on a conversion rate of 130 yen/dollar. U.S. economic tradition has been to attack monolithic structures in the interest of market/profit-based competition to give more options to smaller companies and new industry entrants. IBM found itself twice in anti-trust litigation and more recently AT&T was downsized. The U.S. culture and USG policy viewed these corporations as having unfair strengths leading to unfair competition. I must add that even though we as a culture are proud of our innovative environment and in fact, it is clear that many in Japan seek to imitate it, the USG has portrayed a certain and, if I may use the word,

schizophrenia about U.S. company structure and so then about U.S. industry structure. Lauding our innovative culture would naturally result in a great number of small innovative firms. This is clearly true in the electronics industry. Large numbers of U.S. firms are competing for the same revenue dollar. If companies are not government contractors, these revenues provide the only seedcorn for the small company to grow to a medium size company. Cray Research has traditionally funded all R&D through its sales and only now is Cray beginning to look at government R&D as a source of complementary technology.

Japan understands the notion of a certain critical mass that is necessary to establish and maintain global leadership when market share oriented national policies are followed, rather than the strict profit motive of the U.S. In this former case, deep pockets are necessary to carry out a long-term policy against your competitors. The player with the deepest pockets wins. Obviously, companies the size of Cray Research and smaller won't be players in this game for long. Over the years, the Government of Japan has "encouraged" a structure of only three large computer firms, in order to ensure the country's competitive strength in world markets. The forms that this encouragement have taken have been discussed in many fora and are all a part of the strength we now see from the Japanese computer industry--where supercomputers are merely a leading edge product of a higher volume computer industry.

For the U.S. supercomputer industry, if you look at all the firms, this is clearly not the case. The industry has many players and participants. All of them fund future R&D by competing in the same market segments. The schizophrenia aspect comes from the fact that now USG policy makers are saying Cray Research is too small to compete for the long term. We are hearing this now, even from within the USG, even from trusted

friends and users of our most leading edge products. These friends, like many other senior policy makers in the USG, I assume, look across the ocean and observe the results of the structural differences of the two countries' industries. And they are amazed. They look at Cray Research, the U.S. industry leader; they look at our size; our manufacturing capacity; the numbers of technologies we depend on others for and they throw their hands up at the disparity of the company resource structures. Then they look around at the large, industrial scions of our country; the very scions that were in earlier years under attack for anti-trust, and these policy makers say aloud "thank God for large companies." Both Japan and our own U.S. policy makers are implying the same thing: small cannot compete with big. Thus the schizophrenia.

Naturally at Cray Research, and downstream at Cray Computers, we are very distressed at the defeatism expressed in this attitude. I would hope that subsequent congressional hearings would deal with the structural issues of high technology industry between Japan and the U.S. - for all U.S. industry - not just supercomputers.

Today, the U.S. supercomputer industry embodies technological leadership. Even though Japan has achieved accomplishments in the componentry arena, supercomputers are an architecturally complex system. It is not enough to be great in one area; the critical factor is how the various functional elements fit together; how the I/O system interacts with the operating system; how the memory system interacts with the processors, etc. Cray Research is the unquestioned leader in the architectural balance necessary for sustained gigaflop performance on a broad-range of real-world problems of leading edge science and technology. The Japanese to date have not mastered the interplay of the elements of the architecture and have not offered more

than one processor to be used against any problem. We do not count and should not count on this situation continuing. They are very committed to their goal of supplanting U.S. leadership and they are very open to acquiring technology from wherever it is available.

The U.S. leads in other areas important to the continued leadership of the industry: software, algorithms; and parallelism. The Japanese have announced an intent to have their first parallel machine. The U.S. supercomputer industry has had parallel systems for sometime. It is important to understand that there is more to parallelism than just having extra processors in the cabinet. To leverage the parallelism in order to address more advanced problems of science and engineering--the true benefit of using supercomputers--these processors must be able to work efficiently together against the same problem. This has great implications for how the science problem is mapped into the language of the supercomputer - the algorithms. It is also critically dependent on the ability of the software to manage, detect, and efficiently exploit the parallelism of the problem. The U.S. is the unquestioned leader in these areas, both in the industry as well as in R&D activities of the federal government.

An important driving force of the supercomputer industry is the quest to solve leading edge problems of science and engineering. The solutions to these leading edge research problems by supercomputers enables a computational approach to complement the traditional approaches of experimentation and theory, as we seek basic understandings to complex problems. It is the application of the supercomputer, the resulting codes and results of their use that provide benefits beyond those of the supercomputer industry itself. It is understood that economic prowess will go to the country that has the best tools to address these leading-

edge problems. Thus we have aggressive interest by Japan and the U.S.; and Europe has now picked up the banner.

Government-funded R&D directly helps the U.S. supercomputer industry with these application codes. These application codes get developed as a part of leading-edge research activities. This means that critical sources of these applications codes, algorithms, libraries, etc., are our universities and our national laboratories. The Japanese participate aggressively in these two sectors in the U.S. The importance of the university sector can be seen by the very intense attention that has been paid to it by Japanese supercomputer companies. The university and national laboratory research are the seedcorn for the country and so for the U.S. supercomputer industry in terms of these application codes and innovative R&D. The U.S. industry currently leads in the shear number of application codes that can address great numbers of science and technology areas. Japan has indicated that they plan to catch up.

Many engineering graduates of U.S. universities with supercomputers today are familiar with supercomputer power and have been trained in computer simulation, computational methods, and vector processing. The availability of these trained resources will help spur the growth of supercomputing, particularly supporting the continued development of the commercial sector. Obviously, USG support for university research directly helps the supercomputing industry. And to the extent that the graduates of our university are U.S. citizens, this support will directly help the U.S. supercomputer industry. Foreign graduates are an important source of current strength, but as they return to their homes to help develop their own indigenous industries, they will not necessarily continue to be available to the U.S. industry. I am describing yet another perspective of our continuing discussion of the critical nature

of the educational pipeline issue. This also points up the value of the NSF Supercomputer Centers programs and other such programs that are focused upon getting the effective use of supercomputers into the infrastructure.

Market analysts agree that outside the U.S., the next highest growth market for supercomputers is Japan. The Japanese supercomputer market is expected to grow at a significantly faster rate than the U.S. We think that this market growth will be closer to 30%, compared to the anticipated 10% of the U.S. market. This market picture points up the importance to the U.S. supercomputer industry to having significantly better access, in the near term, to the Japanese market than what we now have.

In the commercial sector of the U.S., only leading edge firms have purchased supercomputers outright; other U.S. industrial firms take advantage of the NSF Supercomputer Centers and other sources of supercomputers cycles. Japan, perhaps more than the U.S., sees supercomputers as essential tools of R&D. Japan has a larger industrial and university commitment to supercomputing than we do, and it applies its supercomputing technology primarily to enhance the competitiveness of its commercial industries. Japan has significantly more supercomputers in automotive, chem/pharm/biotech, construction and electronics than we do in the U.S. The U.S. uses more supercomputers in aerospace, petroleum, and research, traditional areas of U.S. strength. Furthermore, the U.S. focuses its supercomputers extensively in design. In a recently completed study performed under the Japanese Technology Assessment Program (JTECH) on computer integrated manufacturing for Japan's semiconductor industry, it was noted that Japanese semiconductor companies routinely use supercomputers and that supercomputers are seen as necessary tools of development--not as esoteric instruments of research.

Role of United States Government in Supporting the U.S. Supercomputing Industry

The USG can play an instrumental role in fostering the health of the U.S. supercomputer industry by continuing to drive the use of supercomputing technology. It can do this by purchases of products in a timely manner. It can also work across a number of "fronts" to reduce the risk to U.S. industry to using this technology. Most importantly, USG should help accelerate the entire process. Because the U.S. is the technology leader, delays in adopting technology will benefit the followers. Accelerating the process will help ensure the U.S. lead over Japan. Each time a USG agency decides not to go forward with a planned acquisition of a supercomputer or delays a purchase for several years, it reduces the money available to continue to develop the leading edge technology needed to remain in the forefront of the industry, and reduces the likelihood that sales alone will be able to fund future R&D.

A statement or action plan from Congress encouraging government customers in Department of Defense, Department of Energy, National Aeronautics and Space Administration, National Science Foundation, Environmental Protection Agency, National Oceanic and Atmospheric Administration, National Institute of Health, and others to go forward with supercomputer purchases in a workable procurement time frame, so that this technology can be used to further their research in a cost-effective manner would be helpful. Areas which have a great impact on the government sector include, but are not limited to: Aerospace design, environmental and weather modeling, cancer research, weapons design, nuclear reactor design and control, human gene mapping and basic research. The researchers in these disciplines would

greatly benefit from using the fastest and most powerful supercomputers available.

Another way the USG can provide assistance to the industry is in the area of procurement policy. USG supercomputer procurements fall under the umbrella regulations for ADP equipment. The ADP acquisition regulations is intended to address administrative applications and to reduce costs of acquiring and managing data used to run the functions of government. These rules and the mandate of the Competition in Contracting Act of 1984 require multiple vendor bids for government contracts. This Act and the ADP regulations are predicated on the action of a mature industry, when there are several competing products to choose from, competition therefore lowers costs to the Federal Government. U.S. supercomputer vendors do not address administrative problems. They are leading edge "tools" of R&D design and operations - enhancing experiment and theory approaches to research and development. Supercomputers have various definitions but the most commonly used is that supercomputers are the most powerful computer in the science and engineering marketplace at any given point in time. With the demise of ETA, Cray Research is the only vendor of domestic conventional supercomputers. While we support the intent of the Competition in Contracting Act to encourage competition, lowering the technical standards in order to force the situation of more than one vendor to bid would be damaging to Cray Research and the continuance of our advanced technology efforts. Furthermore, this action could impede the development of certain leading edge applications to critical technology challenges faced by medical research, space, basic research and the defense communities, by not having the most powerful supercomputer to use.

We request that supercomputers be taken out of the purview of ADP procurement regulations. Interim use of sole source contracts

for supercomputers to prevent the lowering of technical requirements should be preferable to reducing the technical standards. For the longer term, it would be important to define supercomputers as R&D design and operational tools, recognizing their value for both economic and national security, their leading-edge uniqueness, and their importance to government sponsored R&D. They are handled in a special manner in regard to export control policy, so it would not seem unreasonable to give them special consideration on the Federal Government procurement side.

The USG could, in fact, provide significant assistance concerning the issue of export controls. The export control process is critically important to companies such as Cray Research. For Cray, 37% of our installed base is in the international market and last year 50% of our orders came from customers outside of the United States. A cohesive export policy which balances the national security implications of supercomputer exports in a way so as to not prejudice U.S. vendors against their Japanese counterparts is important for the U.S. industry.

This is a crucial period for the U.S. supercomputer industry, and the ability to obtain export licenses for international sales, especially to newly industrialized countries, is vital for our growth. Each sale lost to the Japanese reduces the money available to U.S. industry to develop the leading-edge technology required to stay at the forefront of this industry.
Additionally, we at Cray Research consider our worldwide customer base to be one of the most important advantages we have over our Japanese counterparts. This is due to the fact that our systems act as "technology receivers." Our customers, through their use of our supercomputers, transfer back to us important technology and information which enables us to enhance and accelerate our system development efforts. If we are not able to obtain export

licenses for these potential customers, this information so critical to future product development could flow to Japan and not the United States.

Finally, it is vitally important that a rational supercomputer "definition" be developed for export control purposes which takes into account the rapid advancement of the technology and ensures that the extraordinary supercomputer export controls are only applied to the leading-edge, state-of-the-art technology.

The USG can also help the U.S. supercomputer industry with regards to market access into Japan. Despite the fact that the U.S. supercomputer industry has 96% of the market outside of Japan, U.S. vendors have not been able to penetrate the Japanese public sector supercomputer market at all. Although U.S. sales to the Japanese private sector have increased, U.S. vendors have not been able to sell any systems to the public sector.

In 1987, a U.S. Government Section 305 study found that U.S. firms were being excluded unfairly from Japan's Government and public university market. Therefore, the U.S. negotiated a special procurement agreement with Japan in August 1987. This agreement calls for a transparent, non-discriminatory procurement process. Despite this agreement, U.S. companies have not been able to sell one supercomputer to the Japanese public sector in a competitive arena. The only two purchases of U.S. supercomputers by Japanese Government entities were done on a non-competitive basis under a one time only 1987 import promotion budget. If the success of an agreement is judged by results, then this agreement would have to be termed a failure since no U.S. sales have resulted. U.S. suppliers continue to find themselves excluded from serious consideration in Japanese Government procurements due to technical specifications favoring incumbent Japanese suppliers and extraordinary Japanese Government supercomputer

budgets which effectively require massive discounts by the vendors of up to 80% off list price. Accordingly, supercomputers were included in Super 301 as an example of "exclusionary government practices in Japan" which bar foreign suppliers.

Success in the Japanese public sector market is critical to the future success of the U.S. supercomputer industry. It is estimated that by 1993 the Japanese public sector market will be worth 1.3 billion dollars, the approximate size of the entire world-wide supercomputer market in 1988 ($1.36 billion). To put this in perspective, if the U.S. had 25% of this market, it would be worth 300 million dollars, or approximately 40% of Cray's 1988 total revenues. Cray traditionally invests 15-20% of its revenues in R&D. 15% of $300 million would be $45 million. This $45 million represents 50% more than was spent on the development of Cray's most successful product, the X-MP series and almost as much as Cray has spent on its most advanced project, the [illegible]ht processor Y-MP. Clearly, if Cray is to maintain its worldwide technological leadership, we must have access to the Japanese public sector.

Also, we believe that Congress should develop and pass legislation that promotes and even accelerates the use of supercomputers in our national infrastructure. America leads the world in the design and manufacturing of supercomputers. But the benefits do not come merely from the creation of the machines, but from their use. Legislation that recognizes and addresses this issue would be of great help to our industry. We don't believe that we can rely on the pace of the market system to provide the type of infrastructure that is needed to solve our sectoral problems in a time frame commensurate with the competitive situation. An initiative coming from Congress that would act as a catalyst to get governmental agencies and private companies to join together and fully utilize the enormous

benefits that can be realized through high-performance computers would be of great help. We need to more rapidly deploy supercomputers into the infrastructure to reap the benefits.

Our foreign competition understands the importance of a unified effort and governmental support for advanced computing. We believe it is timely for Congress to address these problems in legislation that would call for a comprehensive interagency federal approach for supercomputers and software in an effort to maintain and extend the U.S. lead and articulate new mechanisms for industry involvement and improved mechanisms to aggressively transfer the results of R&D back to the supercomputer industry. Any plan should provide adequate funds to support the type of activity that is needed address challenges facing our industry such as I have discussed here today. High-performance computing can dramatically affect our ability to compete as a nation in a variety in high-tech markets. Government action properly applied can have a large impact on the future of the industry.

Finally, given the importance of supercomputing to the nation's scientific and engineering achievements, the Federal Government must ensure that high-productivity, state-of-the-art computing resources are available to the NSF Supercomputer Centers. The NSF Supercomputer Centers need the continued funding support and commitment from Congress to maintain their focus on frontier applications for our nation's researchers.

Thank you again. I would be happy to respond to any questions.

Mr. WALGREN. Thank you very much, Mr. Rollwagen. Appreciate that interesting testimony.

Mr. Thorndyke?

Mr. THORNDYKE. Thank you, Mr. Chairman, for the opportunity to talk with you today and committee members. I'd like to go into some background. As you know, I'm probably classified as a silverback, as a hard-core technologist, and so I come after supercomputers as the technology trends rather than the marketing trends, which have been handled before.

But early on, in the '60s, when the supercomputers evolved, we bought standard components from the merchant market, innovatively packaged and brought onto the marketplace with very little software, and cooperatively worked with the most advanced users to begin to apply these machines to problems of interest. In the 1980s, we have seen a drastic change in our technology in that the integrated circuit, or the large-scale integration, has forced us now into a much different methodology of design, or simulation. And in fact very little quantities—few quantities are purchased from the semiconductor company, and therefore there is very little semiconductor competition to encourage this very high front end cost, and therefore the economics are drastically different.

In the mid-1990s or further, the semiconductor manufacturing is likely to be the only fabricator of a supercomputer because of the very custom nature of the technology and the custom nature of the fabrication. And as such, then, the supercomputer itself is going to be a function of marketing, applications, software. This does not mean that U.S. companies are cut out. It means the U.S. companies are going to end up having a different role than I say we had in the 1970s and early '80s.

The above trends, if correct, then position the Japanese better than the United States because as vertically integrated companies they are able to focus the technology into their supercomputers as soon as they decide to put it in production; and, therefore, the technology is also taken to the merchant market where the other people can buy it. And therefore, they have equivalently two sources of income to afford it. In the U.S., as you know, we practice vertical cooperation, where we use suppliers and the suppliers all make a profit. It's interesting that all of our suppliers make a profit, while the supercomputer company makes massive losses for 5 years before he can go to the marketplace to find out if he has a product to sell. And therefore, the economics are drastically different.

I do not believe that today it's possible for any supercomputer company to start anew into this marketplace. The costs are prohibitively high. The risks are prohibitively long. You will not find venture capitalist people that are dumb enough to put money in it, virtually. And, number two, it can only be done by a very deep-pocket company, and even ones we thought we had deep pockets we find out weren't deep enough.

So, therefore, the trends of the semiconductor, which is the very backbone of what we offer. Now that's not meant to say, "Well, gee. It's so discouraging let's slash our wrists." I don't mean that at all. There is—our problems are that the—you ask me to compare Japan with the U.S. I believe that the semiconductor technology in

the U.S. in the research area is the equivalent of Japan. I don't think either one has a significant lead.

However, the vertical cooperation does not allow the technology to get put into an early fabrication condition so the supercomputer people can get at it. In the vertical integration, the corporation can simply commit it immediately into a production line. The supercomputer uses it and, later on it's sold as a component. However, United States, the semiconductor people go out on a marketing shopping role to find out who wants to buy it, and people do not use it right away because they are not aware of the commitment the semiconductor company is going to make to the technology. Therefore, by the time we do commit to it, we're 2 years behind. And what is the solution to that, in my mind, is the U.S. has to commit to proof of concept of technology so the SC people have someone with semi-deep pockets putting that technology into production early on and let the supercomputer people use it, because it's critical. We sell high performance technology. We do not sell low performance machines. And therefore, the supercomputer industry must have access to the most advanced semiconductors in a cooperative effort with our United States Government. Otherwise, I do not see where we're going to get them other than as a 2-year wait for some competitors.

I'd like to say also that, in that scenario that everything is changed from the late '60s and '70s to today, today, because of the very nature of technology, you tool a technology before you design a computer. You tool all the chips. You tool the semiconductor production line, with a trend of miniaturization. You tool a manufacturing plant, and yet you don't have a computer to show. And so you put all your tooling on the front end. Each error is retooled and retooled. And so you have massive front end tooling and design costs, and yet you have very low cost replication. Once you have it tooled, you have the very low cost replication so—as Dr. Kuck was stating. The front end cost is very high. Potentially, the production costs are very low. But yet the front end costs are the ones that everyone has to look at because one is not guaranteed in the final one.

I believe that the supercomputer is a, as they say, a 3- to 5-year minimum design time, and for a company to hit a reasonable break-even is nearly 7 or 8 years of negative cash. That does not entice a lot of people to risk their self into this market. However, I also would hasten to point out that the supercomputer has evolved from simply a CPU that we put peripherals on to now a very elegant computing system, which the CPU is but a component. We keep focusing on the CPU, but I believe the CPU is a component and that networking and peripherals are every bit as much important but, in fact, get very little glamour or even, in fact, very little research funding at the present time.

And certainly I greatly support Senator Gore's super dataway as a step, although I tend to believe that we choose modest goals at times when we should be choosing more aggressive goals. But that's from a hardware technologist has against a marketing person. And, therefore, I really believe that there is significant government cooperation that's needed in the supercomputer industry

today and that can make up for the vertical integration competition that we have worldwide.

With that, in the interest of time, I'll stop now and answer questions.

[The prepared statement of Mr. Thorndyke follows:]

TESTIMONY

LLOYD M. THORNDYKE —

SENIOR VICE PRESIDENT, CONTROL DATA CORPORATION

FORMERLY

CHAIRMAN AND PRESIDENT, ETA SYSTEMS

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

WASHINGTON, D.C.

JUNE 20, 1989

Mr. Chairman, members of the Committee, I am pleased to join you today to discuss some challenges to the U.S. supercomputer industry. First, I should like to outline some recent changes in this technology.

How has the supercomputer evolved from the sixties and where might it go?

In the sixties and seventies we bought standard production components and innovative packaging. Then the semiconductor company was only a vendor and competition existed for business. We purchase thousands of components for each supercomputer.

In the eighties Large Scale Integration changed everything. Now a few integrated circuits constitute the supercomputer of yesteryear, and these special circuits or LSI devices are not in standard production. Each supercomputer uses only a few hundred of such LSI devices instead of thousands. The semiconductor-company has no competition and thus different economics exist.

In the mid to late nineties the semiconductor industry will be the fabricator of supercomputers because completely custom Integrated Circuits and packaging will prevail. Each supercomputer processor will use as few new chips as possible, likely less than 25. The

supercomputer effort will therefore be a Division of semiconductor companies which will market the technology and develop software applications.

The above trends position Japan much better than the United States because their industry is vertically integrated and are merchant Semiconductor sellers. Advance Semiconductors and packaging are available first to their supercomputer then to the market place. They get therefore double returns, i.e., supercomputer sales and components sales.

Rather than Vertical Integration the U.S. practices Vertical Cooperation i.e., every supplier makes a profit while the final product company makes huge losses. The product company must attract and hold the semiconductor companies as vendors while designing a supercomputer that takes 5 years before significant volume exists. Thus the Vertical Cooperation in the U.S. is very different from Japan's Vertical Integration in revenue, dedication, and risks/reward. Corporate fortunes dictate the staying ability of the semiconductor company, not the dedication of supercomputer company. Usually no merchant market exists because the supplier is a custom semiconductor company not a merchant marketer.

The semiconductor research technology of the United States and Japan is generally equal. Neither is "light year's" ahead or behind. However, the Vertical Integration in

Japan commits the research effort to "Pilot Fabrication" or "Proof of Concept" immediately and aims their supercomputer effort to the first use. Their corporate commitment to "Proof of Concept" and supercomputer design has no similar model or dedication in the U.S.

In the U.S. we let the semiconductor research technology lay dormant while the company using Vertical Cooperation assesses the market for such advanced technology, and when finding none, does not spend money to tool the "Proof of Concept" line. Only after Japanese merchants hint at newer higher performance components does the U.S. respond but two years late and again the market is gone due to very low cost production components from Japan.

A solution would be for our government to fund and tool "Proof of Concept" lines and dedicate the output to supercomputer designers. This would keep us abreast of Japan in both semiconductor products and supercomputer performance. This was proposed over one year ago to the Defense Science Board but I have seen no action. There would be clear advantages. (Our nation would gain proven technology for their advanced weapons systems.)

Still another point, is the current confusion in most people's minds over a true supercomputer and Massively Parallel computers. Both may be capable of performing supercomputing but only the supercomputer is a general

all-purpose machine. The Massive Parallel Computer of today is not a general purpose computer, but in reality a special applications computer, i.e., it works well on a particular job. Moreover, the software to coordinate the processor is still evolving and that may well be the case well into the future if not forever.

In my view, there has been a great disservice done to the supercomputer industry by Government/DARPA with enormous funding for Massive Parallel computers and NO funding to support true supercomputer advanced technology. This may be the result of public relations "gee whiz" claims of Massive Parallel performance and a relatively ho-hum nature of true supercomputers. (It is also probably due in part to specific Department of Defense needs that we civilians don't fully understand.) It is interesting that virtually all major high technology companies use true supercomputer's for product engineering, design, etc., and only experiment with Massive Parallel machines in their research labs. Like golf, where one drives for show and puts for dough, in our industry we hear about Massive Parallel exploits for show and use "supercomputers" to get the job done.

Dr. Fernbach has observed that the government is funding literally hundreds of various Massive Parallel computers and related research in universities, but only a few true supercomputers are being designed and only by industry and without government funding. This imbalance is detrimental to

the industrial and national security of the U.S. and must be corrected, I believe. Also the Massive Parallel effort is virtually all hardware, yet we all agree software is the key to effective use and it is generally ignored and inadequately funded at best.

I believe a civilian equivalent to DARPA is needed to encourage and advance industry interests similar to DARPA's current thrust which is to advance the DOD interests. If not a civilian agency then one could consider expanding DARPA's charter to include industry expertise, direction and a special budget.

Also today the supercomputer system's requirement for networking and Mass Storage Systems are virtually ignored. Because it may be foreign to them, most supercomputer architects tend to ignore these needs which require very large sums of money, risk and dedication. Since not enough money exists, the architects concentrate on the Central Processor and some software. Networking and Mass Storage Systems are not very glamorous so they have few champions. However, the imbalance of supercomputer performance and network/Mass Storage must be addressed with more funding for prototypes if we are to impact the next generation of systems in the nineties and beyond.

High performance networking is of also great concern but I see little coordinated effort in this area since most companies

and others believe that if Personal Computers are networked, that is the volume market. Supercomputer networking is a very small market now, so of little interest to most companies and the performance risk and research money required to develop such networks are high.

The Japanese recognize these areas now ignored by the U.S., particularly if one reviews the range of new peripherals technology that they have introduced.

We in the United States contend that because the Japanese have not announced Massive Parallel computers we, therefore, have a great lead in supercomputing.

I don't buy that. The Japanese are very practical marketing people, i.e., don't get too far ahead but concentrate where the large market will be shortly. This approach has allowed them to produce faster single processors than the U.S. and they will gradually connect a few together as U.S. industry learns how to use effectively such combinations. Because of their Vertical Integration and support the Japanese will always be capable of volume manufacturing and the ability to come to market with lower prices due to their semiconductor merchant market. Since Massive Parallelism is still a research tool, Japan can afford to wait until much better software evolves, probably in the next decade, before introducing such a system. This strategy allows Japan to observe the U.S. research effort and choose the most promising. I believe that Massive Parallel

hardware is no technical challenge thus everyone including the USSR is capable of linking together combinations of small processors.

Today, the true supercomputer is only designed by U.S. and Japan. Does our government want to loose this lead and reduce ourselves to Massive Parallel systems that everyone in the world can build?

Remember some of us believe one fast supercomputer is better than ten slow Massive Parallel processors regardless of the specific problems industry wants to solve. Further, ten supercomputer processors are better than one hundred or more Massive Parallel processors. You can extrapolate further.

We must continue and emphasize true supercomputer advances and the government must be willing to join as a partner in the required software development efforts, peripheral and networking support and in so doing provide real funding to U.S. industry.

I thank you.

Lloyd M. Thorndyke
June 20, 1989

Mr. WALGREN. Well, thank you very much, Mr. Thorndyke.

Your emphasis, Mr. Rollwagen, on Japan being more aggressive in the use of supercomputers, and the emphasis on the future being in their application, is that sort of more of the same of how they have gotten to where they are in higher technology, where the actual success on developing and marketing seems to pull all good things with it? Can we expect supercomputers to develop well unless we start at that application end and try to pull it into being?

Mr. ROLLWAGEN. The easy answer to both your questions is yes and yes. I do think that this is similar to the kind of approach that Japan has taken in the past in their industry. I think it is directly related, myself, to the cost of capital in Japan, which allows for investment, a large capital investment, to be made and paid out over a long period of time, and the low, single digits, for instance, percent return on investment is acceptable. You take a $20 million computer and expect to make, say, 15 percent on it. You better start making money right away, and you better make a lot of money. And what would that be? I guess $3 million a year, and you better that to your management and to your shareholders quickly in this country. That's very difficult if you're starting from scratch. So built into Japan, there's a way to make large scale investments and to be patient in the payoff from those investments. But often, if you are, the payoffs are enormous in the long run and reward the patience significantly.

Yes, I believe, too—and the point of your second question—that if we're ultimately going to be successful in supercomputers, where we should be successful in a meaningful way, it is in the application of those supercomputers and building that into our own U.S. competitiveness, our own ability to develop new products. And one way—I'm probably going a little beyond my actual knowledge here, so please take this with some caution—but I think in the last couple decades the Japanese have shown us very well that we can make things for a lot less money than we thought we could make things. And we've learned that lesson. You can see it happening in U.S. industry.

They have also shown us, following that, that we could make things a lot better, with higher quality than we thought we could, for less money than we thought we could. And we have learned that lesson too, and I think that's coming through. I think the third stage is just happening now. Is that Japan is in the process of showing us how to design products that are better in the first place, and this is showing, in my opinion, in the automobile industry particularly. And I think to some extent the use of technology like supercomputers plays a role in that, and design is critical. It's again that knowledge base that's built into the product, and we have learned how to do that.

One final point. I don't want to sit here saying that therefore U.S. industry is bad, and I want to sort of just gripe about it. I think it is our responsibility in the industry, if this is really true, to demonstrate to U.S. industry in fact that it is true and to deliver to them the appropriate tools and support to apply the technology effectively.

Mr. WALGREN. But how do we get over that cost of capital hurdle? That seems sort of an immutable nut in a way.

Mr. ROLLWAGEN. It's right here in Washington, D. C., I believe. It has to do with the Federal deficit and—primarily, in my opinion, the Federal deficit. I mean—we're getting far beyond supercomputers now, but I think the rules are set—yes, I think the rules are set in this town. I also believe that the way the tax system is set up that there is a great preference expressed for borrowing money instead of for investing money—dividends, interests are taxed, interest expenses are deductible. I mean, it is just very plain. So those are much larger macroeconomic issues, but I think that's where it is.

Mr. WALGREN. Yes. Yes, I see.

Mr. Thorndyke, your emphasis on the importance of there being essentially a society decision or government support of the development of prototypes, I gather, or the actual development of the—demonstration of the machine almost, is that—

Mr. THORNDYKE. I wouldn't go quite that far.

Mr. WALGREN. I guess I don't see how it can happen when the costs at the front are so high and the risk so large, unless there is substantial support to make that happen.

Mr. THORNDYKE. I may have confused a little. When I talk about significant Government support, it's in the generation of the technology, semiconductors that the supercomputer people can get at without having to fund the entire cost themselves for the establishment of a production line and early—and the feasibility of that pilot fab line operating.

Today, if one wants advanced integrated circuits, you fund that whole effort. However, in vertical integration, a supercomputer, if the corporation funds it, but there's a merchant market outlet. And that's why I was suggesting that the very research technology is going to be put into some type of pilot fab or proof of concept simply for the Department of Defense; and, therefore, the supercomputer people, by getting access to early Department of Defense funded technology, is on a par now with what's available outside of our continental.

Mr. WALGREN. I see. So I guess the point I was missing is that the semiconductor is the building block of the machine. And it's not so much that the machine is that costly to develop, but you have to have the building blocks in a certain configuration, and those must be made quite from a new design or from scratch.

Mr. THORNDYKE. Yes.

Mr. WALGREN. I see.

Mr. Boehlert.

Mr. BOEHLERT. Mr. Rollwagen, you said in the 90's every scientist and engineer will be using supercomputers in his or her work just about every day. Is it going to say "Made in USA" on most of those computers? What do you think; what do you foresee?

Mr. ROLLWAGEN. That's sure our objective.

Mr. BOEHLERT. I know that's your objective, but—

Mr. ROLLWAGEN. I believe that we have that opportunity; and, if it doesn't say "Made in the USA", it's because we booted it. I don't think—By me, I mean collectively we.

Mr. BOEHLERT. Mr. Thorndyke, how would you respond to that question?

Mr. THORNDYKE. I would be greatly disappointed to see a majority of that not being U.S. manufacturing—manufactured. The reasons for that are many, not that I believe that the other people cannot produce proper machines. But as John said, we learn how to use these machines, and we learn all the time.

My experience has been that people buy the current supercomputer as almost a cost reduction of what they're currently doing, and three to five years from now it is not doing any of that work but picked up all brand new work because it offers an opportunity to do something you can't do now. So supercomputer really is bought, when the dust settles, for what it's going to do, not what it can do. But who can write a procurement to say, I want to buy this machine but I don't know what I'm going to use it for right now. But just trust me, in five years it will be turning out more value than it cost you. That's exactly what's happened in the last 20 years. It's going to happen in the next ten. But how does one justify that?

Mr. BOEHLERT. You know, the casual observer looks and sees NEC and Fujitsu and Hitachi, those are three biggies in Japan. They look here and they see Cray and Cray. I would think that one could easily conclude that, with that spirited competition in Japan, and with the absence of competition—although I understand you're trying to create competition, Cray versus Cray—

Mr. ROLLWAGEN. It's working.

Mr. BOEHLERT. Is it? I wish you well.

Mr. ROLLWAGEN. Talk to some of our folks.

Mr. BOEHLERT. But where's the cause for optimism?

Mr. ROLLWAGEN. I think to some extent the past is a lesson for the future. We're very fortunate in this country and in our company that for the last 15 years—talking about our company in particular—we have been able to maintain that technological leadership against much larger competition.

I think there's a reason for that. I think it has to do with fleetness of foot—that the technology is still developing rapidly enough and the power of the increased speed is still significant enough that there's great incentive to go as fast as you can; and to take risks in doing that; and to change the rules in doing that, to try some new technology or some new architecture; and being willing to take a risk with what we've done in the past to take a sharp left turn.

Sometimes I make the analogy with the old "Roadrunner" cartoons, where you escape the wolf and he goes off the edge of the cliff. That still characterizes our business to some extent, and we believe that Cray and Cray, the way it is now, is fleeter of foot than Cray was two months ago and is much fleeter of foot than Fujitsu, Hitachi, NEC or even IBM, especially IBM—I don't know—that that is worth quite a bit.

But it's also changing. The point that Lloyd was making about semiconductors is significant. We used to be able to go buy parts and put together a machine. In the first four years of Cray research, the total expenditure was $8.6 million for everything, all the people, all the pencils, all the parts. For that $8.6 million, we

got Serial I, Cray I, and half of Serial II, so a computer and a half for $8.6 million. That's all it took to get going.

The two machines that we're working on between our two companies now, the Cray III and the C-90, will each cost, I would say, about $200 million, each, to build the first copy. So that's changed. We're fleet of foot but there are a lot more zeros in front of the decimal point.

Semiconductor technology is a big part of that. So far we've been able to keep up. We're an integrated manufacturer now. We make our own semiconductors. But I still believe that we have the fleetness of foot, plus we have the resources to dedicate to this development. I was going to say in terms of dollars going into specifically supercomputer development, I believe that Cray Research—I can't prove this for a fact—but I believe that Cray Research puts more money into that specific technology than any other single competitor that we have. I mean, we're up there. We're ranked as well. We just don't have all this other stuff.

Mr. BOEHLERT. You know, we talk—and you were so right to place emphasis on the Japanese and what they're doing with respect to application, versus what we're failing to do. One of the big problems we've had in the past is that we haven't had the base of people knowledgeable on the use of supercomputers. that's why we were so enthused in this subcommittee as we launched supercomputer initiative, so that we have kids at Cornell and Princeton and Carnegie Mellon and the others, Cal Tech, learning all about it.

Mr. ROLLWAGEN. Right.

Mr. BOEHLERT. Would you suggest we should do even more, and is five supercomputer university research centers enough?

Mr. ROLLWAGEN. No, absolutely not. I mean, if it's really going to be every scientist and engineer, some time during school all those scientists and engineers ought to get exposed to supercomputers.

Mr. BOEHLERT. Do we need more centers or the network? Would the network take care of the need for more—

Mr. ROLLWAGEN. Both.

Mr. BOEHLERT. Both?

Mr. ROLLWAGEN. I mean, the network will breed—I mean, this is self-serving. If we get the network out there, it will breed tremendous demand for more computation, because if I can use it, I want to use it.

Mr. BOEHLERT. Right.

Mr. ROLLWAGEN. If it's as simple as, I'm bringing on my screen in a local work station the Cray Icon, and I go quick, quick on my mouse, and I initiate a process on a computer a thousand miles away, but I get the answers like that. I'm going to do that as often as I can. So putting in the network will create demand for the big computers, and it ought to be made as broadly available as possible.

I think there should be more intercept centers. I recognize, however—and you should, too—that the NSF program stimulated additional universities across the country with other kinds of support to do the same thing, so that I think—

Mr. BOEHLERT. We're proud of that.

Mr. ROLLWAGEN. —when Ken Wilson was here the first time, there was probably only one supercomputer in a U.S. university,

probably the University of Minnesota. I know when he was here. And then there were several in Europe. That's turned around. I mean, there are a lot more here, but we're still under 30. I mean, that's, in a sense, trivial compared to the amount that ought to be there. And that's counting both the NSF program and outside. There needs to be substantially more in order to create the people skilled in using this technology.

Mr. BOEHLERT. This question may not be as far reaching or far afield from the subject as you might think initially, but are you for the proposed reduction in capital gains tax?

Mr. ROLLWAGEN. Yes, I am. In the current tax environment—I'm not as excited as I was when the rates were higher—but I do believe that capital gains taxes are counterproductive in terms of economic development and ultimately revenue for the U.S. Government. And I believe that in the statistics, I think, show that during the period when we did not—first when we did have the capital gains differential and we didn't have it and investment in new enterprise went down and then we did have it and it went back up again. In the meantime, the overall rates come down substantially, so the difference is smaller. But I do believe in it.

Mr. BOEHLERT. Mr. Thorndyke, do you have an observation on that subject?

Mr. THORNDYKE. Yes. I'm very concerned with the lack of aggressiveness in the venture capital people, where we tend to depend on most of the early start-ups, believing that six months and three months worth of a software program is all they want to fund. And when you start looking at some very long-range, difficult risky developments, they're disinterested. I believe that the long-range success in the United States is, in fact, to encourage those types of investments and that the investment rules should be changed to, in fact, encourage it, rather than discourage it. But to find five-year investment, it's unheard of, and yet we should have laws that, in fact, will allow such investment. Of course, I had felt that capital gains should be eliminated on a five-year development for five times or ten times what was invested, to encourage money to go into those long-range developments because the spinout falls all over in other industries.

One very aggressive, long-range development has tremendous spinouts. However, I see very little benefit for producing another computer game in a three or four months—

Mr. BOEHLERT. Of course, where the Japanese beat us hands down is that they have a longer vision. We tend to think of the next fiscal quarter, not even the next fiscal year.

I want to thank both of you for exceptional written testimony, which I have read very carefully, and for your oral presentations here today. It's very helpful to us.

Mr. THORNDYKE. Thank you.

Mr. ROLLWAGEN. Thank you.

Mr. WALGREN. Thank you, Mr. Boehlert.

Mr. Campbell.

Mr. CAMPBELL. Thank you, Mr. Chairman.

This has interested me greatly, the discussion of the absence of capital in the United States. It leads to a suggestion that was in your written testimony, Mr. Thorndyke, concerning consortia activ-

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ity, the possibility that American firms who might not otherwise individually get into supercomputers might in a consortium do so. It ties in with a point that Mr. Rollwagen made concerning the need to work with customers, that your best asset is your customer base, that it may not be adequate sufficient—it may not be adequate to the task—simply to allow a consortium in research and development, but rather to take that down to a level of dealing with customers.

I'd like to ask you, first of all, do you accept that? Do you think that is an important role for the American supercomputer industry, and secondly, what steps have been taken so far on the building of a consortium concept in supercomputers? Mr. Thorndyke and then Mr. Rollwagen.

Mr. THORNDYKE. I'm not aware that there has been a significant step. Certainly we have tended to informally build them because of the very nature of our vertical cooperation. However, it's more of a profit motive than it is a dedicated effort, profit motive being a supplier/vendor relationship. There is more of that type of cooperation in the software and application side but not in the hardware side.

One of my concerns, however, is that you always must have the hardware ahead of the software, but at the same time the software ends up eventually going for years and year and more and more application, where the hardware stops and people go to the next one. So, therefore, computers—early on we look at hardware, but where the real growth and the performance increases comes from software, not from hardware.

Mr. CAMPBELL. If I may interrupt, then the consortium of which you just described is a vertical consortium as opposed to a horizontal one, provision of quality products, in this instance semiconductors, and then down to your consumers.

Mr. Rollwagen.

Mr. ROLLWAGEN. Well, Congressman Campbell, I think you're on to something that is very important that's emerging in the industry. If I can define consortium rather broadly, in terms of including things like strategic alliances or ways to work together, I think it's quite clear—it's becoming clear to us, at least—that no one single company can provide the breadth of services and technology that are required to, in fact, deliver the power of a supercomputer to an individual scientist and engineer at his or her desk.

This is reflected inside our company by an organization that we put together a couple of years ago. It has kind of a funny name, called the "Three Pigs". It stands for third party interface group, 3 P-I-G. So it's the "three pigs" group. We find that our lines are going all over the place in various ways, and even to competitors.

Now, this isn't turning out to be—and maybe this is what you had in mind—some specific development work on a supercomputer architecture or particular design for a supercomputer, but as Lloyd said earlier, that's just the tip of the iceberg anyway. That's just sort of a nit. It's just part of it. I mean the networking, the software, the applications, the work stations, et cetera, the storage devices, et cetera, are all a part of what we're calling network supercomputing. That's what the service really is, what the product really is.

We have a very close technical relationship now, for instance, with Motorola. We manufacture all the parts—the logic parts, not the memory parts—but all the logic parts inside Cray Research for our current YMP product line. But we're doing that because we've licensed technology from Motorola, which is their key leading edge technology. In return, of course, they have an opportunity to produce the technology and production volumes for us. That's one illustration.

We're considering right now—I won't talk about it too much because we haven't done it—but a joint venture, for example, in the biotechnology area, so that we can bring together supercomputer technology with the requirements of molecular modeling on the part of the real practitioners in a way that maximizes our impact. We work with other computer suppliers because often, for instance, even with IBM, we'll have IBM and Cray computers installed at the same time, at the same place, carrying on complementary work within an overall system.

What we have chosen not to do—and I think that makes sense for us, at least—is to set up a joint project to build a specific supercomputer. That doesn't seem to be necessary. I mean, you need somebody kind of in charge, a designer.

Mr. CAMPBELL. It interests me that you haven't. I see all the benefits of those consortia that have existed, but to the extent that both of you emphasize in your testimony the absence of venture capital, the absence of seed money, God knows the absence of Federal Government money given our present budget condition, I would have thought that a source of money would be the industry itself in a consortium concept to, for example, have an economy of scale, non-overlapping research and development which otherwise might have occurred.

Mr. ROLLWAGEN. We wouldn't be opposed to that. The situation hasn't come up, and to some extent we share the cost with Motorola for the work that we do together.

Mr. CAMPBELL. I have one other line of inquiry. You had mentioned, Mr. Rollwagen, the importance of dealing with our potential foreign competitors, that when we sell our knowledge, all we get is dollars, or yen, and when we buy it, we've got twice as much as we had before.

It brings to mind an issue that was hotly contested just a short while ago, the FSX deal, and the argument about that. I wondered if it would apply here as well. Is there not a risk, that if we do export extensively, as perhaps we will at the end of the Super 301 hearings, our supercomputer technology to Japan, that we will be giving them an advantage in a field where presently we have an advantage?

Mr. ROLLWAGEN. If you mean exporting the hardware to install in Japan, the answer is no, honestly, because the business moves fast enough that about the best thing for us that we could get from out competitors is if they copied our existing machine. By definition, it would put them about five years behind. Not that you can't learn from our existing machines, but it's not very direct. And besides, the design of the machines in that sense is in the public domain anyway. I mean, you can get the reference manuals and

you can—So moving the machines there, no, does not present, in my opinion, a technological exposure.

Mr. CAMPBELL. The greater risk would be the sharing of technologists, if that were to occur.

Mr. ROLLWAGEN. Perhaps.

Mr. CAMPBELL. If I'm not putting words in your mouth, do you agree or not?

Mr. ROLLWAGEN. If they're—Well, obviously we train Japanese nationals of all kinds working for us and others in how to maintain the equipment. Is that what you're thinking, that sort of thing?

Mr. CAMPBELL. Well, I was. One of the aspects again of the FSX deal, not to get too far into that, was the sharing of the actual working relationship.

Mr. ROLLWAGEN. Yes, but that's different because the machine, the FSX itself, is going to be designed and manufactured on a joint basis.

Mr. CAMPBELL. To return to our topic, just one last line of inquiry, you were asked by my colleague concerning the capital gains tax. I take it both of you would also support making permanent the R&D tax credit and making it not only incremental but cumulative. It seems to me that, to the extent right now you only get an R&D tax credit for research you did this year and you didn't last, companies that have been in the business for a long time don't get much of a return for that.

Am I correct in my presumption?

Mr. ROLLWAGEN. Yes. They're easy.

Mr. CAMPBELL. And my last question, just to bring me back to my own graduate days, you mentioned Newton and Descartes in your opening, and you said this is new. This is the third way of learning. Is this what I learned in statistics as Monte Carlo sampling, is that what this is? You just do it 20 million times and you learn a pattern, as opposed to Descartes would have theorized a pattern and Newton only watched an apple drop once?

Mr. ROLLWAGEN. That technique is certainly used, but it's not the exclusive technique. The point is that, with computers, the simulations based, in fact, on Descartes kind of theory, as modified by observation. The simulations on computers are complete enough and accurate enough that it's almost more real than real life. The benefit is that, in effect, you can run physical—if I can put it that way—experiments on the computer faster, cheaper, more safely, and you can run experiments that you can't do in real life that are just physically impossible to do but you can on the computer. So you can explore much larger solution spaces is really the significance of it.

Mr. CAMPBELL. Thank you, Mr. Chairman. I can't wait until we model the American economy—

Mr. ROLLWAGEN. They're doing it, the Federal Reserve Bank in Minneapolis, on a Cray II.

Mr. WALGREN. All right. Well, let me just thank you both for your contribution to today's testimony. We appreciate all that went into it and appreciate being able to talk with you as a resource to the committee.

Mr. ROLLWAGEN. Thank you.

Mr. WALGREN. Thank you very much.

The third panel, Dr. Sheryl Handler, who is the President of Thinking Machines Corporation; Rodney Rougelot, President and Chief Executive Officer of Evans & Sutherland Computer Corporation; and Terrance Rock, Vice President of Convex Computer Corporation.

I wanted to recognize the gentleman from California for any special introductions that he might like to add along with the Chair's welcome. Mr. Campbell.

Mr. CAMPBELL. I thank you, Mr. Chairman, and I applaud you for holding these hearings. I've learned a great deal at these hearings and I think you're far-sighted to have held them.

It's a pleasure to draw attention to a Mountain View company, Evans & Sutherland, whose chief executive officer will be giving us testimony this afternoon, Mr. Rougelot, and whose cofounder, Dr. Dave Evans, is here as well and is seated immediately next to Mr. Rougelot at the table.

First of all, just a word or two about Dr. Evans, the founder of Evans & Sutherland Computer in Mountain View, CA. He has his Ph.D. in physics from Berkeley, 1953, and in 1954 was one of the pioneers of the personal computer and then turn into the field of interactive graphic technology. He is also the first chairman of the University of Utah's Computer Science Department. So perhaps we'll find out if there's computer modeling of cold fusion today.

I think Evans & Sutherland is a good model, as a base for computers in modeling and simulation, and that is their forte. Mr. Rougelot is now the CEO of Evans & Sutherland, with a background in electrical engineering at Cornell, and for a while served on the faculty at Yale. His expertise is in computer generated image technology and visual simulation, in which Evans & Sutherland is surpassingly good.

I thank you, Mr. Chairman, for the courtesy of allowing me to introduce the gentleman from this business in my district.

Mr. WALGREN. Thank you. We appreciate that very much. Those individual relationships between constituents and Members of Congress are really important. I'm pleased that Congressman Campbell has such a good base for science and technology in his district and helps the committee out a great deal.

Well, let's go through the panel in the order in which I introduced you to the record; so we'll start with Dr. Handler. We would be pleased to hear you.

Ms. HANDLER. Thank you.

Mr. WALGREN. Ms. Handler?

STATEMENTS OF SHERYL HANDLER, PH.D., PRESIDENT, THINKING MACHINES CORPORATION, CAMBRIDGE, MASSACHUSETTS; RODNEY S. ROUGELOT, PRESIDENT AND CEO, EVANS & SUTHERLAND COMPUTER CORPORATION, SALT LAKE CITY, UTAH, ACCOMPANIED BY DAVID C. EVANS, CHAIRMAN; AND TERRY ROCK, VICE PRESIDENT FOR OPERATIONS, CONVEX COMPUTER COMPANY, RICHARDSON, TEXAS

Dr. HANDLER. First, may I ask you—I do have a bad cold, and if you can't hear me please, let me know.

Today I'd like to tell you why we think the country that leads the world in high performance computing will also lead the world as the high performance economy. We are in an age of economic, not military, confrontation, and high performance computing is the essential ingredient in leadership in science and in business.

First, I would like to talk about the importance of supercomputing to the economy. Second, I would like to review our lead in a new wave of supercomputing. And third, I'd like to look to the future and describe how we can capitalize on our lead in this new technology.

There has been a lot of publicity lately about the strategic importance of supercomputers. It is all true. Those with access to the biggest computers achieve the deepest understanding. Two hundred years ago, Napoleon said that "God is on the side of the largest army." Today, he would just as accurately say that God is on the side of the largest supercomputers. They are that important.

Supercomputers solve the biggest and hardest problems. First, they help us to make sense out of our largest databases. We have spent years accumulating massive amounts of data only to find out that it is very difficult now to access it. But with today's new supercomputers we find that this wealth of data becomes practicable for the first time. The new supercomputers, in essence, can find a needle in a haystack. They can access a single document from amongst millions, and do it in real time. Physicians could search the entire National Institutes of Health medical database to look for rare disease cases and treatment protocols, and businesses could pinpoint statistical and demographic data to help them make product decisions and to adjust to changes in demand. Scientists could find the results of experiments that are done halfway around the world.

But supercomputers can also do the reverse. They can see the forest through the trees. They can spot trends in streams of millions of pieces of information, and these capabilities are vital to businesses as they expand and compete on a worldwide basis. But just to underscore the importance of databases, I would like to remind you that when an aerospace company delivers a jumbo jet, the documentation that they deliver weighs more than the airplane itself.

The second way supercomputers contribute is by helping scientists understand Nature. It is hard to understand an ocean because it is so large. It is hard to understand a molecule because it is so small. It is hard to understand nuclear physics because it's so fast. And it's hard to understand the greenhouse effect because it is so slow. Supercomputers break these barriers to understanding. They, in effect, shrink oceans, zoom in on molecules, slow down physics, and fast-forward climates. Clearly, a scientist who can see natural phenomena at the right size and at the right speed learns more than one who is faced with a blur.

Now, until recently, supercomputers have been very expensive and, therefore, relatively few have used them. But this state of things is changing, and therein lies the opportunity, the biggest opportunity for America. There is a new wave of computing emerging that is offering many times more computing power than today's biggest supercomputers, but cost less.

What is this new wave? It's known as parallelism, and the highest performance version of parallelism is called massive parallelism. The concept is simple. If you have a problem with millions of pieces of data, the fastest way to compute—the way nature does it—is to compute on all of the data at once. This is true for both scientific and business applications.

Since many people have referred to massive parallelism, I thought I would give you just a very brief sort of metaphor to think of it. Imagine having a pail of water. And you want to move the water from one pail, which is the memory of a computer, to another pail, which is the processor. Now traditional computers do this by taking an eye-dropper and moving it one drop at a time. Now the goal then is to move it as fast as you can, as fast as the speed of light. Parallelism is an attempt to move more than one drop of water at once, and control parallel machines try to move, let's say, 8 or 10 or 20 drops of water, and so it goes back and forth, moving all those drops simultaneously. Massive parallelism differs because what it does is it takes the entire pail and, "Kerplunk", dumps it into the processor. So all of the water, all of the drops, all of the data is moved at once, and that is a significant departure from the way we've been doing computing for the last 50 years.

Now massively parallel supercomputers enable us to achieve performance of a billion operations per second and up at prices starting in the hundreds of thousands of dollars. This makes supercomputing affordable by those who now buy minicomputers and mainframes.

Now, for the first time in the history of computing, massive parallelism enables us to build supercomputers that are increasingly faster, while simultaneously bringing the cost down. That's never been true before. In the past, when you've wanted to bring the cost down, you've basically delivered less performance; or, if you wanted to build faster machines, the cost increased. But now we can build machines that are vastly more powerful than today's computers and bring the cost of performance down at the same time.

More powerful supercomputers means bigger and tougher problems will be solved. Cheaper machines means that more users will be able to harness and exploit supercomputers. More will be done by more people, and this is very American. But will America take the next step?

America is the unequivocal leader in parallel processing. We know how to experiment and how to innovate. But are we going to capitalize on our investment in building a dominant market position both here and abroad? That's the question. Are we going to capitalize on our investment? Or, like High Definition TV, are we going to let our technology quietly slip away to others who see the economic potential and make a hearty commitment to it?

Now what's the reason this might happen? We're faced with a double transition in the supercomputing industry in America. One transition is that we must now adjust to a highly competitive world in supercomputing. America used to have a virtual monopoly in supercomputing, and that has ended. The other transition is that we must move and expand from traditional supercomputing into parallel machines. This dual transition is both the good news and the bad news.

The good news is that, while we are battling it out with foreign competition in traditional supercomputing we are leaping ahead in parallel computing. The bad news is that Europe and Japan are not far behind.

Many countries recognize the potential for parallel processing. In fact, even before the U.S., Europe and Japan had large government programs to build these new machines. American innovation prevailed nevertheless, and we reached the goal first. But the foreign appetite is already strong and sophisticated. Both Japan and Europe are determined to be major players in this field, and I'd like to comment that this hasn't been true in the past. When we've led the world in the past in supercomputers or in PCs or in work stations, we had a substantial lead before other countries caught on. But in this case other countries caught on at the same time or slightly before us. We just happen to be more industrious and more clever and built the machines first.

We, on the other hand, are so used to being the leaders in supercomputing that we do not have the same sense of urgency about using the new parallel supercomputers that other countries do. As an example, many of our leading Supercomputer Centers have not committed to these new parallel architectures because they are waiting for the software to mature. By the time this happens, we will find ourselves buying the hardware overseas from those who set out to win.

The Federal Government must make it clear that we cannot and will not cling to our U.S.-bred conventional supercomputing technologies while others adopt the newer wave of parallel processing in order to leap-frog us. We should not abandon our traditional supercomputers, but we must embrace this new wave while it is emerging. That's what's critical.

In order for America to solidify its lead in parallel supercomputing, we must do two things better than we have done in the past. We must get American users onto these new machines very quickly and broadly. We must also export overseas with great gusto.

And so the recommendations that I would like to make today have several parts.

The first is we must increase the pace at which parallel supercomputers are being adopted and used domestically. The Federal Government should have a mandate and require plans of all DOD, DOE, NSF and other agencies, plans for how we're going to incorporate this new technology into our science, our research, our business.

The second step is to ensure that our parallel supercomputers become the standard internationally, and this is the point that John made very well. There are three big markets: Europe, Japan and the U.S. It is very important for the U.S. to get to Europe and Japan with our technology now, while we have a lead. It's essential that our technology become the standard hardware internationally and that will only happen if both Europe and Japan write their software for our machines. The U.S. must have a clear and consistent export program to enable our parallel supercomputers to quickly get a foothold overseas. There should be no barriers to exporting our supercomputer hardware to Europe and Japan.

The third step that you've heard a lot about today is to make sure that America retains its lead in software, and we think the best way to do that is a program that has the flavor of "Let a thousand flowers bloom" to encourage universities and small companies and research organizations to develop software. And, in particular, I would like you to consider making available some form of tax credit to companies that buy software for new parallel machines. This would stimulate those who are currently taking the conservative, "wait and see" attitude. The resulting heightened demand would cause much more software to be written more quickly. Now, in an uncompetitive environment that we used to have in supercomputers, that wasn't necessary. But, in the present Japanese-European-American competitiveness, we have to address the issue that Europe and Japan is out to beat us, and we have more of a relaxed attitude because we are already the leader. So we have to spur and stimulate software being developed in a very aggressive way that recognizes that life has changed.

Another recommendation that we would like to make is that we very aggressively encourage DARPA to continue its funding of advanced machines. I know we're designing machines right now that are hundreds of times faster than today's largest and fastest computers, and this program must be intensified and must be funded through DARPA. We're going to be doing it anyway, but we know that the more development that goes on in this country the better off we'll all be.

And, finally, I'd like to mention that the high-speed network proposed by Senator Gore is a very good idea. It would enable every scientist and student and researcher to have access to supercomputers. Right now the number of people that have used supercomputers in this country is measured in the thousands. That should be in the millions.

So, in summary, supercomputers are used to solve the biggest problems and the hardest problems. Our country cannot afford to lose its competitive edge in high performance computing. Either we learn to take quicker and better advantage of our supercomputers or they won't be built in the U.S. any longer. It is that simple. This country must be the first to have every scientist, every business person and every student using supercomputers. If we do this, we will do better science; we will build better products; and we will operate our businesses with more information. And that is what it will take to be the high performance economy of the 1990s and beyond.

[The prepared statement of Dr. Handler follows:]

Thinking Machines Corporation

Sheryl Handler, Ph.D.
President
Thinking Machines Corporation

Testimony
The House Subcommittee on
Science, Research &Technology

20 June 1989

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Congressional Testimony

House Subcommittee on Science, Research and Technology

Sheryl Handler, Ph.D.

Today I'd like to tell you why the country that leads the world in high performance computing will also lead the world as the high performance economy. We are in an age of economic - not military - confrontation and high performance computing is the essential ingredient of leadership in science and in business. America's goal should be nothing less.

First, I'd like to talk about the importance of supercomputing to the economy. Second, I will review our current lead in a new wave of supercomputing. Third, looking to the future, I will describe how we can capitalize on our lead in this new technology

I. The Importance of Supercomputing

There has been a lot of publicity lately about the strategic importance of supercomputers. It is all true. Those with access to the biggest computers achieve the deepest understanding. Two hundred years ago Napoleon said that God is on the side of the largest army. Today, he would just as accurately say that God is on the side of the largest supercomputers. They are that important. Supercomputers solve the biggest and hardest problems there are to solve

First, they help us to make use of our largest databases. We have spent years

accumulating massive amounts of data only to find it very difficult to access, even using the largest mainframes. But with today's new supercomputers we find this wealth of data usable, in a practical sense, for the first time. The new supercomputers can find, in effect, the needle in the haystack. They can access a single document from amongst millions, and do it in real time. Physicians could search the entire National Institute of Health medical records for rare disease diagnoses and treatment protocols. Businesses could pin-point the statistical and demographic data needed to support new product decisions and to adjust to changes in demand. Scientists could find the results of an experiment done halfway around the world.

Supercomputers can also do the reverse. They can see the forest for the trees in these very large databases, spotting trends in a stream of millions of pieces of information. Such capabilities are vital to businesses as they expand and compete on a worldwide basis. Just to underscore the importance of databases to our economy, remember that when an aerospace company delivers a jumbo jet, the documentation often weighs more than the airplane.

The second way supercomputers contribute is by helping scientists understand Nature. It is hard to understand an ocean because it is too big. It is hard to understand a molecule because it is too small. It is hard to understand nuclear physics because it is too fast. It is hard to understand the Greenhouse Effect because it is too slow. Supercomputers break these barriers to understanding. They, in effect, shrink oceans, zoom in on molecules, slow down physics, and fast-forward climates. Clearly, a scientist who can see natural phenomena at the right size and the right speed learns more than one who is faced with a blur.

II. The New Wave

Until recently, supercomputers have been very expensive and, therefore, relatively few have used them. This state of things is changing -- and therein lies the biggest opportunity for America. There is a new wave of computing emerging that is offering many times more computing power than today's biggest supercomputers, and is also less expensive.

What is the new wave? It is known as parallelism. And the highest performance version of this way of computing is called massively parallel supercomputing. The concept is simple. If you have a problem with millions of pieces of data , the fastest way to compute -- the way nature does it -- is to compute all the data at once. This is true for both business and scientific applications. Many critically needed database applications are impractical without these massively parallel supercomputers.

America is ahead in this new form of computing hardware. That is because America, through the Defense Advance Research Projects Agency (DARPA), took the risk 5 years ago to try new approaches. And it paid off. We have built and begun using machines that are way ahead of the foreign competition.

Massively parallel supercomputer technology enables us to achieve performance of more than a billion operations per second (a gigaflop), at prices starting in the hundreds of thousands of dollars. This makes supercomputing affordable by those who now buy mini-computers and mainframes.

For the first time in the history of computing, massive parallelism enables us to continue to build supercomputers increasingly faster and simultaneously to bring the cost down. More powerful supercomputers mean bigger, tougher problems will be solved. Cheaper machines mean many more users will be able to harness and exploit supercomputer performance. More will be done by more people. That is very American. But will America take the next step?

III. The Future

America is the unequivocal leader in parallel supercomputing. We know how to experiment and innovate. Are we going to capitalize on our investment by building a dominant market position both here and abroad? Or, like High Definition TV, are we going to let our technology quietly slip away to others who see the economic potential and make a hearty commitment to it?

What is the reason this might happen? There is a double transition to be made by America and its supercomputing industry. One transition is that we must now adjust to a highly competitive environment. America is used to having a virtual monopoly in supercomputing and that has ended. The other transition is that we must move from traditional supercomputing to parallel machines. This dual transition is both the good news and the bad news.

The good news is that while we are battling it out with foreign competition in one area

of the industry (traditional supercomputing), we are leaping ahead in another area (parallel supercomputing). The bad news is that Europe and Japan are already on our trail.

Many countries recognized the potential of parallel computers early. Before the U.S., Japan and Europe had large government programs to build these new supercomputers. American innovation prevailed nevertheless, and we reached the goal first. But the foreign appetite is already strong and sophisticated; both Japan and Europe are determined to be major players in this field.

We, on the other hand, are so used to being the leader in supercomputing that we do not have the sense of urgency about using the new parallel supercomputers that other countries do. As an example, many of our leading supercomputer centers have not committed to new supercomputer architectures because they are waiting for the software to mature. By the time this happens, we will find ourselves buying the hardware overseas, from those who set out to win.

The Federal Government must make it clear that we cannot, and will not, cling to our U.S.-bred conventional supercomputing technologies while others adopt the newer wave of parallel processing in order to *leap-frog* us. We should not abandon our conventional supercomputers, but we must embrace this new wave while it is emerging.

In order for America to solidify its lead in parallel supercomputing, we must do two things better than we have in the past. We must get American users onto the new technology very quickly and broadly. We must also export overseas with great gusto.

IV. Recommendations

1) The first step is to increase the pace at which parallel supercomputes are being adopted and used domestically. Federal government departments and agencies, in particular, DOD, DOE and NSF-funded laboratories should have a mandate to exploit emerging new parallel supercomputers.

2) The second step is to ensure that our parallel supercomputers become the standard internationally. There are three big supercomputer markets: U.S., Europe and Japan. Who is going to dominate each market? It's very important for the U.S. to get to Europe and Japan with this new parallel processing technology now, while we lead. It is essential that American parallel supercomputers become the standard hardware internationally. That can only happen if Europe and Japan write their software for our machines. The U.S. must have a clear, consistent export program to enable our parallel supercomputers to very quickly get a foothold overseas. There should be no barriers to exporting our supercomputer hardware to Europe and Japan.

3) The third step is to make sure that America retains its lead in software. The government should put in place a five (5) year program to encourage software development for these new supercomputers. This program should exploit the diversity and entrepreneurialism of America's universities, small companies, and research organizations. "Let a 1000 flowers bloom" should be the style.

4) We should continue to fund DARPA's next generation of parallel supercomputers. DARPA is committed to building even more powerful

supercomputers by the early 1990's. The Federal Government must make sure these machines get put into use in an aggressive and broad-reaching way as soon as they are available. It will not happen on its own accord.

5) Congress should also consider giving some form of tax credit to companies that buy software for parallel supercomputers. This would stimulate those who currently are taking the conservative wait-and-see attitude. The resulting heightened demand would cause much more software to be written more quickly. In an uncompetitive environment, which supercomputing used to enjoy, tax incentives would not have been necessary. In the present Japanese-European-American competitiveness, the U.S. Government must encourage our supercomputer user-community to be aggressive.

6) The Federal Government should move quickly to install the National Research and Education Network proposed by Senator Gore. It is a vital component of the infra-structure of an Information Society. The information age will not be here until you can access the Library of Congress from your desk.

V. Summary

In summary, supercomputers are used to solve the biggest problems and the hardest problems. Our country can not afford to lose its competitive edge in high performance computing. Either we learn to take quicker and better advantage of our new, parallel supercomputers or they won't be built in the U.S. any longer. It is that simple.

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This country must be the first to have every scientist, business person and student using supercomputers. If we do this, we will do better science, make better products, operate our businesses with more information. And this is what it will take to be the high performance economy of the 1990's and beyond.

Mr. WALGREN. Thank you very much, Dr. Handler. We appreciate that.

Mr. Rougelot?

Mr. ROUGELOT. Thank you, Mr. Chairman, for the chance to be here with you today and to participate and, Mr. Campbell, for your kind introduction.

In 1968, David Evans and Ivan Sutherland founded Evans & Sutherland Computer Corporation on the belief that computers were powerful tools for modeling and simulating the world in which we live. They recognized that for such tools to be useful in solving a broad set of difficult problems the computational power of the computer had to be closely coupled to the intuitive power of the human being by allowing the user to interact immediately with a visual representation of the problem. All E&S products embody this critical concept of visualization.

Dave Evans, our founder and chairman and a pioneer in interactive computing, is with me at the table, and we would like now to address the topics that you outlined in your invitation to us.

The technological and financial barriers to entry in the supercomputer market are high. We are now completing the development of our first supercomputer, the ES-1. To date, the project has cost more than $30 million and, in addition, our opportunity cost of capital has risen substantially as a result of the decrease in our stock price, caused by the concern of the financial community over our intent to enter the supercomputer market. The risks we face are still high. The cost of successful market penetration can easily exceed the cost of development.

Our heritage, however, gives us confidence that we can succeed. The company has pioneered the technology on which most of the computer graphics industry is based, and we have developed a broad range of visualization products that are used by our customers in a variety of demanding applications. In a sense, Dave Evans and Ivan Sutherland are to visualization what Seymour Cray is to supercomputing.

Approximately two-thirds of all the visual systems in the world that are used for training civil airline pilots have been manufactured by Evans & Sutherland. During recent years our annual share of that market has been as high as 90 percent. We are also a major force in the military pilot training market. Our visual systems are used by every branch of the U.S. military and by many of our allies. Large aerospace companies use our visual systems to design aircraft and weapons systems, and NASA uses them for engineering, design and evaluation. Our major competitors in these markets include General Electric, McDonnell Douglas, and Singer-Link. In addition to large visual systems, the company also manufactures interactive computer graphics products that are used by automobile, pharmaceutical, chemical companies, government R&D laboratories, universities, planetaria, and many others.

Now, because visualization is such a critical element in the effective application of supercomputers and because it's possible that some of the members of the committee may not have had an opportunity to see examples of high performance visual systems, I would like, Mr. Chairman, with your permission, to show a very short vid-

eotape that illustrates some of the applications previously mentioned.

I think it may be necessary to have the lights off here, and it may be necessary to lower the house lights, so that people can see. If you would do that and then, Jim, if you would run the tape—

[Videotape presentation.]

Mr. ROUGELOT. Now, it's important to remember that the pictures you see are being generated in real time by very large, high-performance, special-purpose computers.

This scene and the next scene are important because the databases or the numerical models which represent the scene you see here have been actually extracted from satellite imagery and aerial photography to develop the 3-dimensional models automatically by computer. This is a very important concept, a massive user of computing power, and very important strategically to our Government.

In addition to generating the picture here, an important simulation of the dynamics of all the elements of the automobile is going on. If you watch carefully, you can even see the suspension react and the steering mechanisms react. Looks to me like the shock absorbers in that car need tuning.

This is a picture that shows the results of a system that we just delivered to Chrysler and Ford for helping them do automobile body styling.

The drug represented here is the first drug designed by a computer, using Evans & Sutherland equipment, and approved by the FDA

Okay, Jim. Thanks. And if we could have the lights.

We've learned during the past 20 years that almost all the economically and strategically important customer applications require both advanced visualization and enormous amounts of affordable, easily programmable, general-purpose computing. To generate the database for the low-altitude, high-speed flight scenario that you have just seen, to compute a new energy-stable configuration of a molecule, or to simulate in real time the dynamics of the vehicle on the road—all require supercomputing power. Without visualization, the computation involved in these applications would be much less useful. Our awareness of this growing need for cost-effective supercomputers and their tight coupling to visualization and our experience with the design and manufacture of very large computing systems were major factors in our decision to enter the supercomputer market.

At the outset, our knowledge of applications and technology convinced us that we could make a significant contribution to our customers and to the overall supercomputer market if we designed our machine according to the following basic principles. The minimum unit of performance must be equivalent to the Cray XMP single processor. The machine capacity must be easily expanded, while remaining competitive in price.

Lower performance would put the user below the threshold needed to run state-of-the-art applications. A single computation for molecular modeling, for example, may take weeks on a minicomputer, making interactive visualization infeasible. Supercomputers can reduce this delay to a few hours, thus enabling the scientist to simulate a reasonable number of hypotheses.

Since the major investment of users is in applications, porting these applications to a new platform must be quick and easy. Programming tools that accommodate new trends and technology without being tied to a particular vendor must be provided. We've had previous questions, I think, from the committee about that issue, and I'd like to add as an aside that we have designed the machine to use UNIX software, using standard work stations that make the user—give the user very easy access to the machine. That also provides for very easy transportability of many existing software programs to the machine.

Supercomputing should be strongly connected to interactive visualization. The high bandwidth required for visualization demands local access to the supercomputer, requiring an architecture that can scale up in performance while still allowing an entry-level system to be offered at a fraction of the cost of traditional supercomputers.

Since we were not tied by history to a uniprocessor design, we chose a parallel architecture, implemented with large CMOS VLSI chips to reduce cost. As another aside, in response to some previous questions, I might point out that we made deliberate decisions to design the equipment using custom chips for many reasons. One of them was that we would be able to have those built in the United States. All parts at the current time, except for the dynamic RAMs in the machine, we obtain from United States vendors.

We also chose a moderately parallel architecture. Though more complex to design than massively parallel systems, this architecture protects the user's investment, minimizes the cost of porting traditional application programs, and allows users to take advantage of existing programming tools and production software. Many experts advocate massively parallel architectures. We believe that they offer no technological price performance advantage for general-purpose supercomputing over the next decade.

With respect to Japanese competition, the importance of application software is demonstrated by the inability of the Japanese to penetrate the U.S. supercomputer market. However, we see the Japanese as formidable competitors, not because they may be winning the peak megaflop war, but because of their determined investment in supercomputer usage. While publicizing their new architectures, such as their fifth generation, they are building a technology infrastructure, creating a strong national user base, and developing applications that use uniprocessor and moderately parallel supercomputing architectures. In only 5 years since the Japanese began installing significant numbers of supercomputers, they have surpassed the U.S. in providing supercomputer resources for scientists and engineers. Large, government-backed consortia are developing programs for the most critical applications, such as fluid dynamics and polymer modeling, and manufacturers are porting U.S.-developed applications to Japanese machines.

A strong national user base and the rapid development of applications will allow the Japanese to control their own market and to penetrate both the U.S. and European markets without the need to develop radically new architectures. The U.S. still has a clear lead in applications and tools for moderately parallel architectures. This lead will be a key factor in market dominance during the next few

years. However, we need to recognize more clearly that supercomputers are vital tools for creativity and innovation, and we must develop a correspondingly strong national market.

With respect to the role of the government, Mr. Chairman, we believe that the Federal Government has a vital role to play in the continued success of the supercomputer industry. That role is primarily as a strong customer. The government must recognize the importance of the moderately parallel architecture and the advantage such systems give us over foreign competitors. The major requirement for a healthy market is to provide useful access to supercomputers for users who can benefit from additional computing power. Current access is much too limited. People with interesting and challenging computer-intensive research applications should have adequate local machine access. We recommend the following actions.

Provide a revolving fund to facilitate purchases by government agencies. This should be accompanied by a simplified procurement process that will allow qualified users to make timely acquisition of systems. This process must recognize that supercomputers are tools of innovation and change, not just large data processing systems.

Increase funding for a large number of public and private universities for development of moderately parallel supercomputer applications. The current NSF Centers are excellent, but they are simply not sufficient to allow adequate access by qualified users with interesting and important research projects. Universities are prepared to extend the state of the art in many areas of science and technology, but they lack money to buy the necessary supercomputers.

And last, encourage the widespread use of supercomputers in the private sector, offering corporations an investment tax credit or accelerated depreciation allowance for supercomputers for use in research applications.

In summary, then, Mr. Chairman, we believe that entry into the supercomputer market is both financially risky and technologically difficult. However, the incentives of our free enterprise system make it worthwhile to try. Our experience in providing very high performance computer tools to our customers gives us great confidence in the future of this market. The Japanese threat is real and significant, but with adequate focus on our areas of strength, including our lead in parallel architectures and applications, we can win. The government should enhance its role as a major customer, as a source of funding for scientists who can innovatively use these new supercomputers.

Thank you very much.

[The prepared statement of Mr. Rougelot follows:]

Statement of

Mr. Rodney S. Rougelot
President and Chief Executive Officer
Evans & Sutherland Computer Company, Inc.

Presented to the

Subcommittee on Science, Research, and Technology
of the
Committee on Science, Space, and Technology
United States House of Representatives

June 20, 1989

MR. CHAIRMAN AND MEMBERS OF THIS DISTINGUISHED COMMITTEE,

In 1968 David Evans and Ivan Sutherland founded Evans & Sutherland Computer Corporation on the belief that computers were powerful tools for modeling and simulating the world in which we live. They recognized that, for such tools to be useful in solving a broad set of difficult problems, the computational power of the computer had to be closely coupled to the intuitive power of the human being by allowing the user to interact immediately with a visual representation of the problem. All Evans & Sutherland products embody this critical concept of visualization.

David Evans, our founder and Chairman, and a pioneer in interactive computing, is with me at the table. We shall attempt now to address the topics that you outlined in your invitation. Thank you for this opportunity.

Entering the Market

The technological and financial barriers to entry are high. We are now completing the development of our first supercomputer, the ES-1. To date, the project has cost more than thirty million dollars. In addition, our opportunity cost of capital has risen substantially as a result of the decrease in our stock price, caused by the concern of the financial community over our intent to enter the supercomputer market.

The risks we face are still very high. The costs of successful market penetration can easily exceed the costs of development. Our heritage, however, gives us confidence that we can succeed.

The Company has pioneered the development of technology on which most of the computer graphics industry is based, and we have developed a broad range of visualization products that are used by our customers in a variety of demanding applications. In a sense, David Evans and Ivan Sutherland are to visualization what Seymour Cray is to supercomputing.

Approximately two-thirds of all the visual systems in the world that are used for training civil airline pilots have been manufactured by Evans & Sutherland. During recent years our annual share of that market has been as high as 90%. We are also a major force in the military pilot training market. Our visual systems are used by every branch of the U. S. military and by many of our allies. Large aerospace companies use our visual systems to design aircraft and weapons systems, and NASA uses them for engineering design and evaluation. Our major competitors in these markets include General Electric, McDonnell Douglas, and Singer-Link.

In addition to large visual systems, the Company also manufactures interactive computer graphics products that are used by automobile companies, pharmaceutical companies, chemical companies, government R&D laboratories, universities, planetaria, and many others.

Because visualization is such a critical element in the effective application of supercomputers, and because it is possible that some of the members of the committee may not have had an opportunity to see examples of high-performance visual systems, I would like, with the Chairman's permission, to show a very short video tape that illustrates some of the applications previously mentioned.

[Video Tape Presentation Inserted Here]

We have learned, during the past 20 years, that almost all of the economically and strategically important customer applications require both advanced visualization and enormous amounts of affordable, easily programmable, general-purpose computing. To generate the data base for the low altitude, high speed flight scenario you have just seen, to compute a new energy stable configuration of a molecule, or to simulate, in real-time, the dynamics of a vehicle on a road — all require supercomputing power.

Without visualization, the computations involved in these applications would be much less useful. Our awareness of this growing need for cost effective supercomputers and of their tight coupling to visualization, and our experience with the design and manufacture of very large computing systems, were major factors in our decision to enter the supercomputer market.

Market Assessment

At the outset, our knowledge of applications and technology convinced us that we could make a significant contribution to our customers and to the overall supercomputer market if we designed our machine according to the following basic principles:

- The minimum unit of performance must be equivalent to the Cray X-MP single processor. The machine capacity must be easily expanded while remaining competitive in price. Lower performance would put the user below the threshold needed to run state-of-the-art applications. A single computation for molecular modeling, for example, may take weeks on a mini-computer, making interactive visualization infeasible. Supercomputers can reduce this delay to a few hours, thus enabling the scientist to simulate a reasonable number of hypotheses.

- Since the major investment of users is in applications, porting these applications to a new platform must be quick and easy. Programming tools that accommodate new trends in technology, without being tied to a particular vendor, must be provided.

- Supercomputing should be strongly connected to interactive visualization. The high bandwidth required for visualization demands local access to the supercomputer, requiring an architecture that can scale up in performance while still allowing an entry level system to be offered at a fraction of the cost of traditional supercomputers.

Since we were not tied by history to a uniprocessor design, we chose a parallel architecture implemented with large CMOS VLSI chips, to reduce cost.

We also chose a moderately parallel architecture. Though more complex to design than massively parallel systems, this architecture protects the user's investment, minimizes the cost of porting traditional application programs, and allows users to take advantage of existing programming tools and production software.

Many experts advocate massively parallel architectures. We believe that they offer no technological price/performance advantage for general purpose supercomputing over the next decade.

The U.S. Position Relative to Japan

The importance of application software is demonstrated by the inability of the Japanese to penetrate the U.S. supercomputer market.

However, we see the Japanese as formidable competitors, not because they may be winning the peak Megaflop war, but because of their determined investment in supercomputer usage. While publicizing their new architectures such as their "Fifth Generation", they are building a technology infrastructure, creating a strong national user base, and developing applications that use uniprocessor and moderately parallel supercomputing architectures. In only five years since the Japanese began installing significant numbers of supercomputers, they have surpassed the U.S. in providing supercomputer resources for scientists and engineers. Large government-backed consortia are developing programs for the most critical applications, such as fluid dynamics and polymer modeling, and manufacturers are porting U.S. developed applications.

A strong national user base and the rapid development of applications will allow the Japanese to control their own market and to penetrate both the U.S. and European markets, without the need to develop radically new architectures.

The U.S. still has a clear lead in applications and tools for moderately parallel architectures. This lead will be a key factor in market dominance during the next few years. However, we need to recognize more clearly that supercomputers are vital tools for creativity and innovation and we must develop a correspondingly strong national mark[illegible]

The Role of Government

The Federal Government has a vital role to play in the continued success of the supercomputer industry. That role is primarily as a strong customer. The government must recognize the importance of the moderately-parallel-architecture supercomputer and the advantage such systems give us over foreign competitors.

The major requirement for a healthy market is to provide useful access to supercomputers for users who can benefit from additional computing power. Current access is much too limited. People with interesting and challenging computer intensive research applications should have adequate, local machine access. We recommend the following actions.

- Provide a revolving fund to facilitate purchases by government agencies. This should be accompanied by a simplified procurement process that will allow qualified users to make timely acquisition of systems. This process must recognize that supercomputers are tools of innovation and change, not just large data processing systems.

- Increase funding for a large number of public and private universities for development of moderately parallel supercomputer applications. The current NSF Centers are excellent but are simply not sufficient to allow adequate access by qualified users with interesting and important research projects. Universities are prepared to extend the state of the art in many areas of science and technology, but they lack money to buy the necessary supercomputers.

- Encourage the widespread use of supercomputers in the private sector by offering corporations an investment tax credit or accelerated depreciation allowance for supercomputers for use in research applications.

In Conclusion:

- We believe entry into the supercomputer market is both financially risky and technologically difficult. However, the incentives of our free enterprise system make it worthwhile to try.

- Our experience in providing very high performance computer tools to our customers gives us great confidence in the future of this market.

- The Japanese threat is real and significant, but with adequate focus on our areas of strength, including our lead in moderately parallel architecture and applications, we can win.

- The government should enhance its role as a major customer and as a source of funding for scientists who can innovatively use new supercomputer tools.

Mr. WALGREN. Well, thank you, Mr. Rougelot. And, Mr. Evans, we appreciate your being here, and appreciate that contribution to the record.

Mr. WALGREN. Mr. Rock?

Mr. ROCK. Thank you. It's a pleasure and an honor to be here. Basically, I'll summarize the written testimony that you have. I'll basically hit the assessment of competitive position, then move to the alternatives, role of the Federal Government, and finish with comments.

I think the Convex assessment of the competitive position of the high-performance *computer industry today* is that the high-performance market is truly an international market. We see that in our own market; 50 percent of our sales are international. They have been in the last 3 years and continue to be. That's the thought that we have shared in the beginning.

As you see, the U.S. dominates the supercomputer market. Cray dominates the high end, as Mr. Rollwagen so aptly described, and I think you'll find that Convex dominates the mid-range. It's not well known, but Convex has over 300 customers and 475 units in 25 different countries, including 60 systems in Japan—so very, very international.

We believe that the fundamental reason that the U.S. is dominating the high-performance market is the understanding, at least currently, that supercomputing is not just high-performance hardware but, in fact, is really the solution of extremely complex problems using supercomputers. And those supercomputers normally have the attributes of balanced high-performance hardware: strong CPU, I/O, and memory performance, very balanced; outstanding software technology, usually using the UNIX operating system and with strong compilers, well written compilers, usually with the availability of third-party application specific software. We've heard a lot about that today. We, for example, and Cray have hundreds of third-party software packages, application specific and for particular industries and solution to industry problems. And, of course, strong customer service and support, and I can't emphasize that enough. You have to take care of the customer. We do that with technical assistance centers and with strong field support.

So I believe we are in the lead now, but I believe the Japanese can and will develop these strengths. They certainly will. They have the capabilities, and we believe the competitive threat is very serious.

I think the competitive situation exemplifies—is exemplified by the fact that the Japanese Big Three—Fujitsu, NEC, and Hitachi—all have combined revenues of over $80 billion, which definitely give them the financial strength to finance the development of supercomputers and allow them to also discount and control markets. In addition, the Japanese Big Three dominate the semiconductor industry, extremely important to the computer industry. Provides them with advanced semiconductor technology, research and development required to build these supercomputers.

In addition, and probably as important, the Japanese financial system rewards market share focus and long-term strategic actions. The U.S. system rewards a much shorter term, quarter-to-quarter focus. Japanese companies can secure a much lower cost of capital.

Equity capital on the Japanese stock market can be raised at a price-earnings ratio far in excess of the U.S. market. Our Japanese competitors can raise capital, borrowed capital, at a much lower rate than we can in the U.S.

In addition, the U.S. system encourages corporate raiders and takeover specialists, which usually result in large debt, huge debt, which virtually eliminates or reduces the capability for a company to finance research and development or invest in capital equipment, which is absolutely necessary for survival of the U.S. industry.

So, with all that in mind, what are the alternatives that we have today? The alternatives that Convex and other companies will bring to the market, to the general-purpose market—our alternative and position is to provide distributed, more affordable supercomputing, using multiple processors, employing integrated vector and parallel processing technologies, and networked by high-speed interconnects.

The U.S. and America has got to have distributed, affordable supercomputing—access to supercomputing to bring products to market faster, reduce the design cycles, and provide more accurate solutions. Supercomputers are definitely an American competitive weapon, and we need to use them.

So how do I see the role of the Federal Government? Our perspective is that the government should focus in several areas. One, of course, anti-dumping enforcement. We've talked about that. That's to prevent buying market share by large Japanese competitors through heavy discounting. Additional federally funded supercomputer programs. That is, both in government organizations and institutions and targeted industries. Additional support for the U.S. semiconductor industry. We have to have semiconductor technology to build supercomputers. And policies that provide a level playing field in export controls, which you've already mentioned today, are very important in our company also. And government quotas or sanctions by international governments, which we've seen in other areas. And I believe a reassessment of tax policies or other policies that reward and encourage research and development and capital investment, and discourage huge debt and quick fixes and quick, short-term paper profits.

Yet, doing this, at the same time we need to understand that we have to have our Japanese suppliers, and not just move away from Japanese suppliers today. Alienating these suppliers today would dramatically affect the industry and the country in general.

So, in conclusion, we feel the real question is how do we make American industry competitive? The use of U.S. supercomputers is mandatory as a competitive weapon in all of our key industries—that's aerospace, that's automotive, that's electronics, that's pharmaceutical, petroleum, and whatever. We have machines in all of those industries because supercomputers can and do provide superior products with a shorter time to market, which are the two key competitive weapons in global competition for U.S. industry. We must have them. So, protecting the U.S. supercomputer industry is one of critical importance in our mind, and which assures absolutely the competitive nature of the U.S. market in general. So our policies and programs should be aimed at fostering the use of su-

percomputing throughout research, government and industry. And at the same time we need to generate the new tax laws or policies that reward the research and development and capital expenditures which keep our companies and institutions world-class competitive.

Thank you.

[The prepared statement of Mr. Rock follows:]

Convex Computer Corporation
Written Statement
presented to
U.S. House of Representatives
Committee on Science, Space and Technology
June 20, 1989

CONVEX Computer Corporation • 3000 Waterview Parkway • P.O. Box 833851 • Richardson, TX 75083-3851 • 214-497-4000

Convex Computer Corporation
Written Statement
presented to
U.S. House of Representatives
Committee on Science, Space and Technology
June 20, 1989

Convex's assessment of the competitive position of the high performance computer industry in the U.S. relative to that of Japan is as follows:

The high performance computer market is an international market in which Cray dominates the high-end of the market; Convex dominates the mid-range market.

The Japanese computer manufacturers, NEC, Fujitsu and Hitachi, have high performance, fast hardware products. But while this is the case, U.S. high performance computer companies currently maintain the lead in supercomputing, for this reason: supercomputing is not about faster hardware, it's about solving complex problems. The U.S. supercomputer companies are ahead of foreign competition because we understand there are four aspects to supercomputing solutions.

- Balanced, high-performance hardware: There is more to real performance than pure megaflops or gigaflops performance. Unfortunately, that's how performance is commonly measured but these definitions must be properly interpreted. There is much more to useful performance than peak speed, such as software performance, memory performance, and I/O performance. Users care only about the performance of *their applications*--the problems they specifically solve with their machines--and this type of performance is determined by dozens of attributes. In terms of speed, the Japanese have high peak performance, but that's only a part of the supercomputing solution.

- Software technology--Operating systems (UNIX™) and compilers: Maintaining the lead requires being proficient at several software standards. Companies such as Convex and Cray recognized the emergence of the UNIX standard long ago and designed their machines for UNIX--now considered a requirement in supercomputing. Japanese systems have historically been based on IBM standards and only now are attempting to migrate to UNIX. Also superior compiler technology is critical to computing performance and productivity. American companies and research institutions lead in this area, as well.

- Application specific software: Most of the supercomputers in use today, especially in industry, utilize third-party written software applications rather than custom-written software applications. The majority of that third-party software is developed by U.S. based organizations. Convex considers having both a broad array of application software available on its machines and having agreements/relationships with the software developers, as critical elements of its competitive strategy and success. American suppliers are leading in this crucial area.

- Service and support--taking care of the customer: This is a critical component in supercomputing solutions. American companies' reputations in the area of service and

support are superior. American suppliers utilize direct sales and support organizations in all major markets and, as such, are closer to the customer. Outside of Japan, Japanese manufacturers typically use distributors or OEMs for sales and customer support.

It would be naive to believe that U.S. companies will always be able to maintain the supercomputing lead for the reasons cited above without continual development and diligence in these areas. The Japanese can--and will in time, develop these necessary strengths. Thus, we must guard against complacency among U.S. supercomputer companies.

On a more specific level, Convex has been selling its products successfully to the Japanese for over four years. Convex has more than 60 machines installed today in Japanese companies and expects, by year-end 1989, to significantly increase this number. Convex attributes this level of sales activity in Japan to the following:

- Convex supercomputers address a need that Japanese supercomputers do not by offering high overall performance with superior system software and broad application availability at price points that are considered to be affordable by a broad customer base.
- Convex provides support to its customers, distributors, and value added resellers through a direct subsidiary in Japan that is staffed with Japanese nationals.
- Convex uses a stable, established partners such as Tokyo Electron Ltd. and NKK who provide credibility in the Japanese market.

Convex has enjoyed success in Japan and believes in American companies' abilities to maintain the competitive edge in high performance supercomputing. But it also is aware of another potential scenario. Convex realizes that when, or if, the Japanese companies decide that the price/performance market niche that Convex currently dominates is a viable and sizable market for Japan, the competitive threat posed by Japan can become very serious.

The biggest threats posed by the Japanese to American supercomputer companies are:

- The size of the big three Japanese companies is over $89 billion which provides substantial financial staying power. This gives them the ability to mask the success or lack of success of their supercomputer products versus U.S. supercomputer companies, whose existence relies solely on the success of their supercomputers.
- Furthermore, they can afford to not be profitable in the supercomputer market segment for a very long period of time and can buy market share by excessive and unreasonable discounting, while public U.S. companies are forced to live by quarter-to-quarter reporting which represents the results of a single technology focus.
- The big three Japanese computer companies also dominate the semiconductor industry, including advanced semiconductor research and development required to build supercomputers.
- The cost of capital differs substantially for U.S. versus Japanese companies. The U.S. financial system rewards a short-term, quarter-to-quarter focus. The Japanese system rewards market share, which results in longer-term profitability.

- Japanese are heavy users of supercomputers themselves. Their per-capita rate of supercomputers indicates their recognition of the strategic importance of using supercomputers to develop products. This enables them to be more competitive in all key areas of research and industry, not just supercomputing.

The role of alternatives to general purpose supercomputers in meeting scientific and engineering requirements for high performance computing.

Supercomputing can be configured or approached in a number of ways. Convex's perspective is that too much emphasis has been placed on how fast a singular, central machine runs. Convex's position is that supercomputing should be made available to a broad base of users through distributed, more affordable supercomputing, i.e., utilizing multiple processors, employing integrated vector and parallel processing, networked by high-speed interconnect technology, etc.--in addition to appropriately located single, high-end, centralized supercomputers.

Distributed supercomputing has very real impact on the productivity of U.S. industry. By making supercomputing affordable and available to more companies, tens of thousands of scientists and engineers can have access to the power of high performance machines, allowing them to create more unique products and bring those products to market faster.

In the last ten years, less than 300 of the high-end centralized supercomputers have been sold by American companies to industry and research institutions. From Convex alone, approximately 500 distributed supercomputers have been shipped in only four years.

American industry needs distributed, affordable supercomputing power to remain competitive, because:

- Maintaining the lead means that a supercomputer must be used in production environments, not just research environments. A majority of Convex machines are running practical, production jobs in industry.

- Production supercomputing translates into bringing products to market faster. Among Convex's customers, ranging from automotive, to pharmaceutical, to aerospace to oil exploration companies, time to market is the critical competitive factor:
  - Companies such as Ford and GM are striving to reduce design cycles down to three years from the current five year period.
  - Pharmaceutical firms such as Agouron, Bayer and Miles Laboratories are expecting to reduce drug design cycles from eight to five years or sooner.
  - General Dynamics, Boeing, LTV and McDonnell Douglas are designing the National Aerospace Plane and other strategic defense systems.

- Supercomputers are America's competitive weapon

The role of the Federal Government in maintaining a vigorous domestic high performance computer industry.

From Convex's perspective, public policy regarding our industry should focus in these key areas:

- Anti-dumping protection laws: The biggest threat the Japanese pose (as discussed above) is their staying power because of their companies' approaches to new markets and their financial prowess. We must continue to prevent them from buying market share through heavy price discounting.

- Federal government funded programs: The government should assist in making supercomputers widely available to more U.S. government organizations, research institutions and industries because supercomputers are our nation's competitive weapons for all our industries. In addition to making supercomputers more widely available, these government funded programs should focus on encouraging ongoing development of all four supercomputing components: hardware, system software, applications and customer support. It will be through programs such as these that Americans can continue to be superior in developing supercomputer technology.

  The accessibility to supercomputing is healthy not only for the makers of these machines, but for U.S. industrial competitiveness in all markets. To assure our national security and control of our own supply of these competitive supercomputing weapons, the U.S. must maintain our supercomputing leadership; the technology must be manufactured and supported by U.S. companies.

- Additional support for the U.S. semiconductor industry.

- Continuance of a level playing field: We ask the U.S. government to continue with policies that provide U.S. companies, on an international level, to be able to participate in free enterprise--to be able to fairly compete based on products, price and company viability rather than be limited by government quotas or sanctions. This includes international governments in addition to industry.

- Reassessment of tax policies and other policies: The federal government should review policies that reward short-term focus and huge debt, and replace those policies with policies that reward research, development and capital expenditures so that American companies and factories can become more competitive worldwide.

- Reliance on the Japanese: A final key point is that the Federal government must realize that U.S. supercomputer companies, as well as virtually all American computer companies, depend on Japanese components, such as semiconductors, in the design and building of American-made machines. Alienating the Japanese could result in their restricting or eliminating supply of these components to American companies--which would be disaster for the U.S. computer industry. In addition, the U.S. relies on Japan for innovation in the key electronic components on which our machines are based. Therefore, in developing U.S. trade policies that impact the Japanese, it is

critical that our government enable the "level playing field" and not dictate supply or pricing or jeopardize our access to the latest technologies.

Other relevant comments

The real American competitiveness question has to do with making our nation's industries competitive. The use of U.S. supercomputers is mandatory to maintaining America's competitive edge in *all* of our key industries, such as aerospace, automotive, electronics, pharmaceuticals, petroleum, etc.--not just in supercomputing manufacturing.

It is proven that "time to market " is critical to compete in the global marketplace. And using supercomputers to design and develop products shortens the "time to market" window for every company that uses the technology. Convex is concerned that the Japanese have a higher per-capita use of supercomputers than U.S. companies, which will (and already has in many cases) enable them to be more competitive in certain industrial areas.

We encourage the federal government to act on the bigger picture. Protecting the U.S. supercomputer industry is critical not only to the few of us in this business. More importantly, assuring an American supply of supercomputers is critical in maintaining our competitive edge in all our key industries. Government policies and programs should be aimed at fostering the use of supercomputing throughout American research, government and industrial facilities.

At the same time, it is a requirement that we generate new tax laws or policies that reward expenditures which keep our companies and institutions world class, competitive and ensures a level playing field.

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FACTS

CONVEX Computer Corporation
3000 Waterview Parkway
Richardson, TX 75080

CONVEX COMPUTER CORPORATION--At a Glance

FOUNDED	October 1982 -- Dallas, Texas
LOCATION	3000 Waterview Parkway Richardson, TX 75080 (214)497-4000
DESCRIPTION	CONVEX, a leading manufacturer of supercomputers worldwide, designs, manufactures, sells and services high-performance systems. CONVEX systems are used by engineers, scientists, and technical users in universities, private industry and government to solve complex problems in such diverse areas as aerospace simulations, seismic processing, computational chemistry, energy analysis, signal and image processing, computational fluid dynamics, structural analysis, graphics and industrial visualization.
FINANCIAL	CONVEX Computer Corporation is listed on the NASDAQ National Market System under the symbol: CNVX. Annual 1988 revenues were $105.6 million.
EMPLOYEES	850 worldwide
SALES/SERVICE	CONVEX has sold more than 475 systems in some 25 countries. The systems are sold and serviced through direct sales and an extensive distribution network. CONVEX has 30 sales offices in the United States and nearly 20 in other countries. The installed base now represents more than a quarter billion dollars of cumulative revenues from more than 300 customers worldwide.

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CONVEX -2-2-2

REPRESENTATIVE CONVEX CUSTOMERS

Ford Motor Company	Stanford University
Texas Instruments	General Dynamics
Nissan Motor Co. Ltd.	LTV Aerospace & Defense
3M Company	BASF
EDS/General Motors	Miles Laboratory
Rockwell International	British Aerospace PLC
General Electric	Agouron Pharmaceutical
BP Exploration	NASA
Seismograph Service Ltd	Notre Dame University
Texaco	Northwest Airlines

PRODUCTS

The C120---
* CONVEX entry-level vector/scalar system
* Performance levels up to 20 megaflops
* Up to 1 Gigabyte of physical memory
* 80-megabyte-per-second I/O bandwidth

The C201-C202---
* Midrange, expandable processors
* Low-cost entries into line of parallel processing systems
* Performance levels up to 46 whetstone MIPS (32-bit)
* Up to 2 Gigabytes of physical memory
* 200-megabyte-per-second I/O bandwidth

The C210---
* Base unit for scalar/vector/parallel processing systems
* Performance levels up to 50 megaflops
* Up to 2 Gigabytes of physical memory
* 200-megabyte-per-second I/O bandwidth

The C220---
* Dual processor scalar/vector/parallel system
* Performance levels up to 100 megaflops
* Up to 2 Gigabytes of physical memory
* 200-megabyte-per-second I/O bandwidth

The C230---
* Three processor scalar/vector/parallel system
* Performance levels up to 150 megaflops
* Up to 2 Gigabytes of physical memory
* 200-megabyte-per-second I/O bandwidth

The C240---
* Four processor scalar/vector/parallel system
* Performance levels up to 200 megaflops
* Up to 2 Gigabytes of physical memory
* 200-megabyte-per-second I/O bandwidth

INDUSTRY STANDARDS

* Enhanced UNIX Operating System
* Connectivity with: Ethernet, TCP/IP, DECnet, Sun Network File System, Apollo's Networking Computer System and HYPERchannel and UltraNet

-more-

CONVEX -3-3-3

COMPILER TECHNOLOGY

* Advanced Vectorizing Compilers that automatically takes advantage of the C Series vector/parallel architecture
* Vectorizing/parallelizing FORTRAN Compiler
* Vectorizing/parallelizing C Compiler
* Vectorizing/parallelizing ADA Compiler

APPLICATIONS SOFTWARE

More than 350 key third party applications software packages for scientific, engineering, technical and financial markets

MANAGEMENT TEAM

L.J. Sevin	Chairman of the Board of Directors
Robert J. Paluck	President and Chief Executive Officer
Steven J. Wallach	Vice President of Technology
William G. Bock	Vice President of Finance, Chief Financial Officer
Frank J. Marshall	Vice President of Engineering
Terrence L. Rock	Vice President of Operations
J. Adrian Wise	Vice President of Worldwide Sales
Frank P. Vince	Vice President of Marketing

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BIOGRAPHY

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TERRENCE C. ROCK

VICE PRESIDENT OF OPERATIONS

RICHARDSON, Texas--Terrence (Terry) Rock joined CONVEX in 1983 as vice president of operations, with responsiblity for manufacturing, materials, facilities security, safety, quality and service operations.

Prior to joining CONVEX, Rock, 42, spent thirteen years with Texas Instruments in a variety of manufacturing and materials functions. Responsibilites included plant management as well as group materials management for facilities in Austin, Houston, Temple and College Station, Texas.

A native of Colorado, Rock received a B.S.M.E. from South Dakota School of Mines and Technology, Rapid City.

CONVEX Computer Corporation, a leading supplier of supercomputers worldwide, was founded in 1982 to design, manufacture, market and service high-performance systems. The company markets its products primarily to scientific, engineering and technical users throughout the world for a wide variety of applications in such areas as geophysical research, computational chemistry, computer-aided engineering, image processing, aerospace simulations and molecular biology. CONVEX, which is listed on the NASDAQ with the symbol CNVX, has sold more than 475 systems in 25 countries. The installed base now represents more than a quarter of a billion dollars of cumulative revenues from 300 customers worldwide. The systems are sold and serviced through direct sales and an extensive distribution network.

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Mr. WALGREN. Thank you, Mr. Rock.

That final point there, that alienating the Japanese could result in eliminating the supply of components essential to the U.S. supercomputer industry and would be a disaster for us, is a—maybe you'd like to elaborate on that a little bit. It's a tough feeling to have, that we are dependent at this point in this industry on the Japanese. How do we go forward in that way?

Mr. ROCK. Well, I think we have to go forward by improving the U.S. industry, giving the semiconductor companies and industry in general a more favorable approach, with tax laws or R&D expense laws or credits and all of those various methods. But somehow we've got to induce the U.S. industry itself. We were basically forced to go to Japan to get the technology to build the Cray I computer and to build the Cray II computer. Now, American semiconductor companies have come a long way in the last 2 or 3 years, and there's a surprisingly good-looking technology coming now from American manufacturers. But we don't know whether that's short-lived or whether that is a new competitive position.

Mr. WALGREN. Is this in the semiconductor chips as such?

Mr. ROCK. Yes.

Mr. WALGREN. And there is one view that we were adversely affected by Japanese marketing policies in semiconductors in particular. Is that correct? And that's the gap that you then had to go to Japan to fill?

Mr. ROCK. Yes, to be able to build the machines in '84, the original machines, and the machines in 1988. To get the technology which allowed us to build the machines, yes, we had to go to Japan.

Mr. WALGREN. And that's somewhat of a lesson of what can happen in this area, isn't it?

Mr. ROCK. I think so.

Mr. WALGREN. Technology as essential as this, if you allow yourself to be damaged, you may not be able to recover without being dependent on, in this case, the country that did the damage. It's a difficult situation. But that should be a very particular warning to us, it would seem.

I wanted to ask, this difference between the massively parallel and the moderately parallel, Dr. Handler and Mr. Rougelot. You're focused on moderately parallel machines, while Dr. Handler is ready to dump a bucket of water on your head, I would imagine. Are these two separate tracks? Are they mutually exclusive. In our encouragement of parallel technologies, do we have to choose between these, given the small nature of Federal pursuit?

Dr. HANDLER. I don't think it's either/or in the same way I don't think traditional supercomputing, the vector computers, neither should nor will go away. It's more or less like jet engines versus propellers. There's a need for both. Or TV and radio. They—on the surface they may seem similar, and why need one or the other? But, in fact, they address different needs. And the massive parallelism lets you build, for example, the teraflop machine, which is buildable in the near term, very economically, through massive parallelism. And that's only a way station. We'll go way beyond that.

The scaling up of machines to get ever more powerful, to be hundreds and then thousands and then tens of thousands of times faster, happens very naturally and very easily with massive par-

lelism. Massive parallelism is definitely the highest performance and emphasis, and there's a lot of computing that doesn't require such a high performance amount of computing. And that's—

Mr. WALGREN. That's where Evans & Sutherland come in.

Mr. ROUGELOT. I concur with Dr. Handler's view in the following sense. I think it's not a choice of either/or. I think the machines are suited—these two very different kinds of approaches are suited to solving very different kinds of problems. Perhaps the most significant example to us of massively parallel machines are our large visual simulation computers, which are very much larger in computational power than the largest supercomputer available today by several orders of magnitude. However, they only do one thing. They only make pictures. We can't use them for general scientific computations. So I think they—in a sense, these approaches will go hand in hand.

Dr. HANDLER. I just want to clarify. I'm not quite sure I'm following what you're saying, but certainly the massive parallelism approach to computing that we're using is going way, way beyond just visualization.

Mr. ROUGELOT. Oh, I understand that. I was not trying to imply that your machines are that special purpose, but rather to say that these are two different approaches suited to solving different classes of problems.

Mr. WALGREN. Um-hum. Um-hum.

Dr. HANDLER. One way I'd liken it is: If you have a symphony orchestra, you have a hundred people in an audience—in the orchestra, and you have a conductor. That's a massive parallelism example. And a chamber group where you have six players playing, as powerful and as interesting and as worthwhile, it's just different.

Mr. WALGREN. Um-hum.

Dr. HANDLER. And the world needs both. And there are different applications that emphasize different—

Mr. WALGREN. I guess the difficulty obviously is that—in trying to bring both into existence at the same time, particularly when we talk about things like particular subsidies, tax credits to pursue given machines and given technologies—there begins to be not enough to go around, and I guess the question is how we could find some kind of fundamental common ground that would bring both of these things to being.

Dr. Handler?

Dr. HANDLER. I don't think the government needs to make that decision. I think the users will make that decision. What the government has to do is to encourage users to be aggressive and to incorporate new technology, and they should decide which new technology. And I think both of us would be comfortable letting the marketplace decide that.

Mr. ROUGELOT. Absolutely. That's my view.

Mr. WALGREN. I see. How can we sort out this dumping business, and going back to what Mr. Rock raised, where he sees the large size of the Japanese companies giving them staying power to essentially ride out or go forward despite yearly losses, and also to offer discounts?

Now, on the one hand, we complain that they are offering discounts, but then we're doing it too. And one of the, I think, legitimate points against the charge that the Japanese were engaging in unfair trading practices as detailed by the evidence was that one of the sites was discounting supercomputers, or failing to let our supercomputers into their public sector, when we, as I understand it, essentially have almost the same policy, if not quite. At least there are no Japanese supercomputers in our public sector, and we specifically put pressure on M.I.T. to make that continue to be the case and not buy a Japanese machine.

So how do we sort out what's good for goose and good for the gander in this discounting area? Is that hard to do? Mr. Rock?

Mr. ROCK. It's a very tough question. That's an extremely difficult question. I think right now it basically centers, though, on university and government installations or institutions. Our particular company does not see it in any of the commercial accounts. Now that's probably partially because we don't have any direct competition in commercial accounts. Mr. Rollwagen can probably address that a little more clearly from the high end.

But it's a very delicate question. And, as you say, it's which side are you visualizing it from, because clearly you can see both sides. So I don't know if there is an easy answer. With universities, discounting is a fairly normal thing virtually throughout the world. With government institutions, there is a lot of not-invented-here syndrome.

So I think, and from my personal opinion, if it went further than that and started getting into the commercial accounts, that would be when I would start to get worried about it, more so than in universities.

Mr. WALGREN. Um-hum. I see. That may be the right distinction.

Mr. Campbell?

Mr. CAMPBELL. Thanks, Mr. Chairman. I would like to follow up that exact point with Mr. Rock.

Do you have any evidence of technical dumping in the supercomputer industry? Technical dumping is the selling at a price in the United States at lower than the price in the country of origin.

Mr. ROCK. Well, as I say, we personally basically don't have any competition from the Japanese side, so we—no, I cannot give you any instance of that. I'd refer that to Mr. Rollwagen.

Mr. CAMPBELL. I'm intrigued by the growth of new entrants, and I'd like to address the next question to Mr. Rougelot. Do you have—in your description of your market, do you have adequate access to capital, and what was the access to capital that Evans & Sutherland derived in order to enter into what, as you described, your investors might have considered a risky and dangerous business?

Mr. ROUGELOT. They did and they do. Our source of capital was, in fact, our own earnings from what has been a very profitable business in visualization systems. I believe that David took an extremely high risk and a bold step when he decided that we would do this. It may be interesting to you, in answer to that question, to perhaps recite in summary how we actually started.

Jean Yves LeClair, who is with us today, our colleague, is the president of the computer division and is the chief, the leader of a

very small group of people who came to us with an idea 3 years ago for an innovative architecture for supercomputers, which for the first time, we believe, exploited custom VLSI circuit technology. Jean Yves first tried to get venture capital in this country to implement his ideas, to form a company and pursue his dream. Venture capital was not forthcoming at all. And it was through Jean Yves' association with David, years ago as a student, that he came to David for advice, not for money. At least I think that's true, Jean Yves.

When David heard the story and thought about our tradition in very large machines and the concept of visualization, it seemed a most natural thing for us to do it ourselves with money that the company had been able to earn through its operations over then 17 or 18 years.

David?

Dr. EVANS. The general-purpose computing—large-scale general-purpose computing was the only component of the modeling system that we didn't supply. And that—it really is a very natural fit in our business, and our customers need it as well. We don't have to find new customers.

Mr. CAMPBELL. Without being indiscreet, did you go to the usual suspects in our beautiful Silicon Valley, the venture capital firms that are there? Did you talk to the usual suspects and ask them for funding?

Dr. EVANS. Yes, we did.

Mr. CAMPBELL. And the answer was negative?

Dr. EVANS. No, not entirely negative. It was a difficult thing for them for two reasons. One is that it's a larger investment than venture capital firms, than venture capital deals usually are. And the other thing is that they are not, the venture capital firms are not equipped, for example, to distinguish between a Convex machine and the machines we're building. And there's a great deal of difference in cost and performance and architecture. And so, you'd wind up—the answer is yes, we could have done it venture capital. We would have had a large number of investors who didn't understand what we were doing, and we thought that might be troublesome. And so, ultimately, we—in fact, maybe the best known venture capital person in the Valley said, "Dave, this is your kind of a thing. Why don't you do it yourself?" But he would have done it. They would have taken it. We could have done it that way, but the conditions and the number of bosses and the ability for them to understand what we were doing we felt made it too hard to do.

Mr. CAMPBELL. Well, I appreciate that elaboration. It would trouble me if I thought that supercomputing was not something that would interest the venture capital community.

Dr. HANDLER. Could I comment—

Mr. EVANS. Oh, it has interested them. They've invested in it in a number of places. They've invested in it in Alliant, for example.

Mr. CAMPBELL. Yes, let's disclose some proprietary information. [Laughter.]

Dr. EVANS. And it's been—you know, it's been—the trouble with venture capital is that all of your dreams don't come true.

Mr. CAMPBELL. Well, they tell us that they're prepared for that.

Dr. EVANS. They are. But—

Mr. CAMPBELL. But not that much

Dr. EVANS. More or less.

Mr. CAMPBELL. Dr. Handler, you wanted to say something on that?

Dr. HANDLER. I just want to, from our experience, paint it sort of vividly. In the past about 12 months we've had about $60 million worth of investment that has been based in the U.S.—$60 million worth of interested investors who made a commitment that they want to invest. We took about $30 million of that. We have had about $250 million worth of investment from overseas that has been brought to—that has made a formal offer to invest, and we've taken none of that. But the difference between 60 and 250 is quite noticeable, especially when we're not talking to any foreign investors and we're not—we have very little of a foreign presence. And, if there's that much interest without trying, it tells you something.

Mr. CAMPBELL. Why did you not take foreign investment?

Dr. HANDLER. Partially because we work very closely with the Defense Department and that's a critical issue to them, and partly because we were able to raise the capital we needed for what we needed to do. But, if one looks forward and plans on growing this company very aggressively, then we would be hampered if we didn't seriously consider the foreign investment.

Mr. CAMPBELL. Two last questions, if I may, dealing with the entry of a new competitor in supercomputers. First, do you find that—and this is directed to any of our panelists—do you find that there are any biases in the United States Government procurement which make it difficult for you to fit specifications in supercomputing for government uses? Have you run into that as a problem?

Mr. ROUGELOT. I don't think we are. Jean Yves, do you care to comment on that?

Mr. LECLAIR. There are several procurements still in the United States which require uniprocess performers, and I'm not open to a widely choice of architectures depending—you know, so the procurement is imposing some architecture because of, probably of the cost of porting the software through new architectures.

Mr. CAMPBELL. I assure you I'll remember it word for word.

And the last question I had is—

Dr. HANDLER. Can I just—can I make a quick comment?

Mr. CAMPBELL. Oh, please. Please.

Dr. HANDLER. From a slightly different angle, I was reading recently that the government was very proud because the GSA now has a new program to buy used mainframes. And, if that's what this country is proud of—I suppose that means that we'll be saving some money. That's exactly the opposite of what we should be doing. We should be, in our government, forcing ourselves to use the most aggressive computing technology, not used mainframes. And I can't remember exactly how much money was involved, but it was quite a few billions of dollars over the course of the next 5 years that was intended to go to used equipment. That doesn't make sense if we really want to be competitive.

Mr. CAMPBELL. I suppose it's better than sinking them on ships for target practice. Another recent alternative use.

Last question was, what is the state of new entry? We have Evans & Sutherland. Do we have any other new entrants in the

supercomputer industry, or any other likely in the near future? Could you give me your nonproprietary guess, any of the panelists, on that?

Dr. HANDLER. Well, we see a combination of other foreign companies that will be entering the U.S., and not just the large ones that you've mentioned. But the foreign companies that are building parallel processors have already begun setting up U.S. activities. And there will continue to be startups. I think that that—the problem is not that there are too few entrants coming on stream. The problem is clearly that American users don't have that thirst, that hunger, to get out in front of anybody because we feel like we're the leaders, and the rest of the world has that thirst.

Mr. ROUGELOT. I think it will be a sad day for innovation and creativity when new startups don't feel the urge and the capability to enter a new exciting market.

Mr. CAMPBELL. Thank you, Mr. Chairman.

Mr. WALGREN. Thank you very much, Mr. Campbell. And on behalf of the committee, we want to thank you all. We have—Mr. Mineta, I'm sorry.

The gentleman from California?

Mr. MINETA. Thank you very much, Mr. Chairman. I just want to very quickly ask, Mr. Rock—on page 2 of your statement you are talking about how successful you've been in the Japanese market. I'm just wondering, had there been a Japanese company that offered many supercomputers similar to yours, do you think you would have been as successful in the Japanese market?

Mr. ROCK. That's a tough question. I would expect that we would have had more trouble than what we had.

Mr. MINETA. And isn't that part of what we're facing right now in terms of our competitive situation?

Mr. ROCK. Oh, yes, I believe that.

Mr. MINETA. Let me ask, if I might, Dr. Handler, I believe you—the issue of software, are we so far ahead in the software field that we can't keep some comfortable margin of competitiveness, or is this an area that we're losing some lead?

Dr. HANDLER. I think we're losing ground there. I think that in traditional forms of supercomputing software—I think the Japanese are starting to show that they are very sophisticated, and there are examples where their software is, in fact, better than ours. And I think it's a myth to believe that software is going to be the hardest thing for the Japanese to produce. I think we'll start seeing clear evidence of that over the next couple of years—that that is not the case.

In terms of software for these emerging parallel technologies, I believe that we do have a minimal lead, but there is an awful lot of technical interest in Europe and in Japan already. They are experimenting, and I don't see that we have a real stronghold there. I do believe that this notion of parallel processing has captured the fantasy and the imagination in both Japan and Europe more than it has in the U.S., and so you have a kind of grass-roots effort going on in both of those cultures that approximates ours—may even be a little bit ahead of it. The reason you don't see as many signs is that we're still ahead in building the hardware, getting it to market. But the users and the technical papers and the emphasis

in the substantive fields themselves, not just software programmers, but the fields of physics and engineering and the various users of software overseas, I believe, are as aggressive as ours.

Mr. MINETA. And where would you say there is the most interest or most activity in this whole issue of development of parallel software?

Dr. HANDLER. Well, I think it's important to recognize—

Mr. MINETA. In the United States.

Dr. HANDLER. Oh, in the United States? Well, I can—our business, I can only speak from our own experience, is about a third universities, a third government, and a third commercial corporations. So it's equally balanced. I think the difference is that the Europeans had two major programs, the Esprit and the Alvie program, which were multi-billion dollar programs to build this—

Mr. MINETA. Funded by whom?

Dr. HANDLER. Government. Various government agencies. And they were very visible, very—highly visible. And the Japanese had the very visible fifth generation program. We had a much less visible program in the U.S. It was visible through the Defense Department's strategic computing program and it was known and seen more by the hardware industry than elsewhere. In Europe and Japan, their programs are visible throughout industry, throughout universities, not just throughout the computer industry. So you have a lot more people thinking, working, talking, curious, interested, by mere virtue of the fact that they have multi-billion dollar programs that are long term. They get a lot of press attention. And we haven't made our goal a very visible one. And I think we haven't because we assume we're the leader, and we don't understand that it's important to have a well-articulated national goal in a long-term, sustained way and that it has to be a whole national goal, not just a computer hardware industry goal.

Mr. MINETA. And what are the sources for the applications software that is being used in your company then?

Dr. HANDLER. They are everything from the oil industry and aerospace industries and defense-related industries and large database industries like Dow-Jones. They come from all over. It's any application that has a lot of data, so it could be molecules and proteins. It could be weather cells. It could be designing an airplane wing. It could be searching a mammoth database. It could be, eventually, the government, if you want to look through the Congressional Record from your desk, being able to type a very easy English command and retrieving from the Library of Congress or any kind of congressional record the information you need very easily. Those are the kinds of applications, where lots of data sits, and they literally are all over, and what is missing is the maturity of software. And what this country is doing is we seem to be waiting for the software to mature, where we see overseas they're trying to do something about it.

Mr. MINETA. Dr. Evans, after—I think you were here when Senator Gore was here, and he talked about networking. I assume that what he's talking about is having computer centers where people would have access from their own locations to these supercomputer centers. How do you—well, how do you feel about that? Do you feel

that rather than having a few supercomputer centers that we ought to have this distributed more—

Dr. EVANS. Yes. As was said in the formal presentation, the NSF Centers have served a great valuable—given us a great valuable service in that they—it was a mechanism by which people could learn to use these machines. But when I talk to people who have now gotten—progressed to where they're dependent on those machines, then they've got to get access to a line from here to another university and from there to San Diego and from there—and then be in the queue. The whole mode of operation in shared computing systems where the capacity of the system is well below the demand of the user set is very frustrating, and people try to do something else, not deal with the problem which needs supercomputing because the access environment is too difficult.

And so I'm believing that we need to—well, I know we can't—we don't have enough money to provide supercomputers for every person, but we must make it possible for people to buy supercomputers. And to use supercomputers, and we're going to have to have the courage to make the decisions of who is so provided. I think we're talking about providing—properly, we're talking about providing supercomputers for people who have problems requiring their use and who are expected to be productive workers. The same kind of difficult decisions we make in NSF in awarding dollars for operating expenses to—

Mr. MINETA. And would you do that, the availability of the machines, by selected targeted industries? Or how would you, in order to get the use of these machines by scientists and engineers?

Dr. EVANS. I think you try to make the—there may be particular industries that for some government purpose we want particularly to strengthen; but, aside from that, we ought to do it on the basis of the scientific merit of their proposals, as we do with many, it seems to me, now.

Mr. MINETA. Senator Gore was talking about biotech.

Dr. EVANS. I believe that is an important part of the next decade's life of the country, and we certainly should be investing in that—in research in that domain.

Mr. MINETA. Medical and pharmaceutical?

Dr. EVANS. Certainly. There are lots of things. And we're going to run out of money, as we always do, but we have to make the hard choices. We can't give everybody 1 percent of a machine. We need to provide facilities for the good research programs, and they won't be in one field over a long period of time. We need a stable mechanism. We need to make supercomputers a normal part of the research environment, where it is required in order to do the work and enough to, as is the case with money, to do some unscheduled things, to seed the future.

Mr. MINETA. Very well. Thank you very, very much to the panel. Thank you, Mr. Chairman.

Dr. EVANS. Thank you.

Mr. WALGREN. Thank you, Mr. Mineta.

And on behalf of the committee we want to express our appreciation to all of you for being a resource to us. Thanks.

[Whereupon, at 5:13 p.m., the subcommittee was adjourned, to reconvene subject to the call of the chair.]

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